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Searching for Information in a Dynamic Book

Stephen A. Weyer

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Report number SCG-82-1

This report reproduces a dissertation submitted to the School of Education at Stanford University in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

Abstract

Information-seeking, search skills are central to many learning tasks, from finding simple facts and comparing events in an encyclopedia, to pursuing complex research questions. Search is part of the larger educational process of inquiry: generating questions and collecting and evaluating information in support of an answer. This dissertation examines the search process and discusses the nature and accessing of information. Traditional books inadequately represent the complexity of information and offer limited access. Electronic books are often only computer-based transcriptions of traditional books. Dynamic books, more advanced electronic books, could become new information sources, ones that evolve to match the complexity of multidimensional information and to help us actively in searching. This dissertation explores the questions of how students look for information and how possible designs for dynamic books interact with the search process.

Electronic and dynamic versions of a world history textbook were implemented in the Smalltalk programming system, and their features described. In an exploratory experiment, 16 eighth-grade students were asked to look for answers to history questions. On one day, students used a paper printout of the book to find information and a simple computer interface to enter their answers, and on another day, used either an electronic or a dynamic version of the book (both referred to here as "computer books"). Students learned to use the computer books with minimal training and preferred them for the given question-answering task. Analysis of group performance data revealed a slight speed advantage for those using the computer books over those using the paper analog.

Observations on student actions, collected by the system which offered the computer books, were used to identify successes and problems of the various tactics for accessing lists of items, accessing the book in its sequential order, following cross references, and marking and returning to items. Student errors were classified as being due to inadequate knowledge about and use of tactics, to inadequate training in operation of the interface, or to the layout and implementation of the interface itself. Differences in search behavior for students using the computer books, specifically in their hierarchical vs. page-oriented access, their subject pattern-matching, and their use of cross references were also emphasized. Directions for future research in search and description, in implementing and accessing dynamic books, and in educational applications are outlined.

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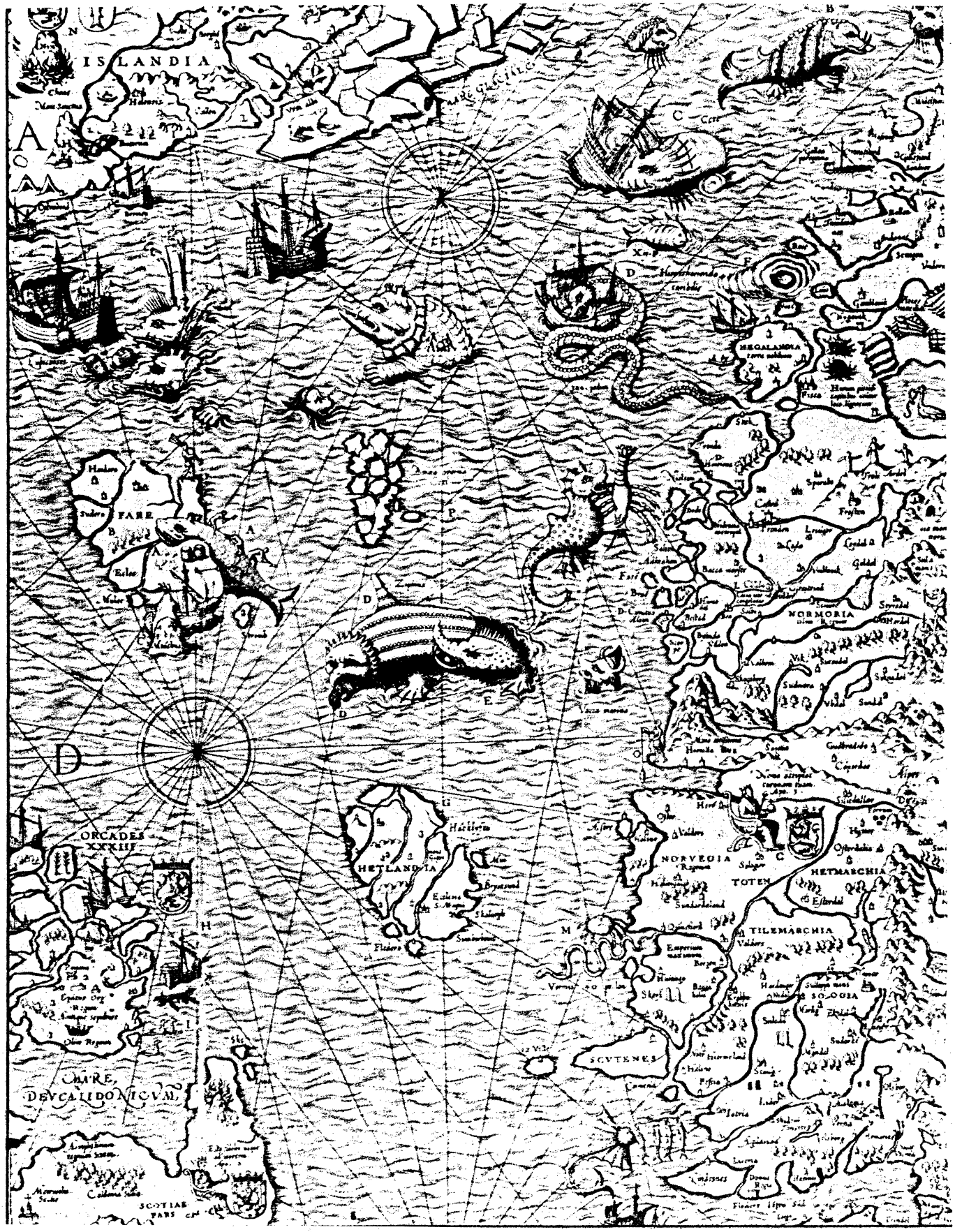

Figure 1-1. A Possible Map of Information (from Atwood, 1977)

SEARCHING FOR INFORMATION IN A DYNAMIC BOOK

Chapter 1. Introduction

> Knowledge is of two kinds. We know a subject ourselves, or we know where we can find information upon it. (from Boswell's *Life of Johnson*)

Navigation Through Information

We are surrounded by oceans of information. There is much flotsam and jetsam floating about, an interesting island and a nearby continent to visit, and possibly buried treasure lying on the ocean floor. There has always been a problem in navigating through these waters: new areas are discovered, old coastlines change, and maps are quickly out of date. Some of our current maps of information resemble the map in the frontispiece (Figure 1-1).

The ultimate size of a map, together with its intended use, determine which details should be included by the map-maker who decides which aspects are important. How significant is the shape of the coastline, the existence of an island, or the naming of cities? Maps are made for different views of the same terrain over time, so they are necessarily a compromise. How do travellers choose which maps provide the best information for selecting a route and for successfully navigating to their destination?

The oceans, maps, and navigation have been introduced as metaphors for information content, information form, and the information search process. This dissertation concerns the search using forms of information to find content. Using the metaphor, this dissertation addresses general questions such as: What happens when new kinds of maps and ways of reading those maps become available? How can we evaluate the effectiveness and suitability of maps? What can we learn from how people use maps so we can design better maps and train better map readers?

Navigation is part of a larger context that includes choosing destinations and making trips as a means to satisfy personal or business goals. Similarly, search is only a component in the larger process of learning. Information-seeking skills enable us to find simple facts, compare similar events in an encyclopedia, and pursue complex research questions. Education, however, should provide us with more than the ability to point to some facts in a book. Of more importance is knowing how to pose the right questions and how to effectively use some information once it has been found. This dissertation explores the central area of search in detail, and suggests the outline of the larger surrounding area, inquiry.

The rate at which our information world is growing compounds the task of searching. Traditional books inadequately represent the complexity of information and offer limited access. Electronic books and libraries, if they are only computer-based imitations of traditional books, do not guarantee accessibility. To be of most use, they should offer the potential of increased availability of information, shared access to up-to-date versions, alternate presentations of information, and active help in searching. These more powerful electronic books can be called "dynamic books."

Versions of dynamic books are inevitable, and will be increasingly faster to access and less expensive to own. The real question for us is how these systems should be designed and evaluated (and not whether they will replace paper books for a variety of tasks). How well do they help people find what they need by providing a set of search operations and a structuring of the information environment? We can use dynamic books to observe and learn about search. Understanding how searching interacts with a given system design can in turn help us to improve these systems. This dissertation examines how people search for information in electronic and dynamic books, and looks at the design of these books and their interaction with the search process.

Dynamic Books

A dynamic book is a new way of interacting with information. Ideally, it should be portable, with all the ease of use we associate with paper books. A dynamic book can react to its readers, not only by changing the medium of the information from text to animated pictures or sound, but also by transforming the organization of its content into a more useful form and by actively aiding the reader in the search process. A dynamic book is a particular view on an interconnected network of knowledge: it may correspond to an actual entity written and published by an author, or it may be a virtual book built by looking at other books and materials from specific points of view. A truly dynamic book does not yet exist; versions have been imagined, however, and parts of one have been created.

A dynamic book is not merely the result of storing an existing newspaper or book on an electronic medium. A book becomes dynamic when it functions as an active transformer of information, as it does when it sums the numbers in a table or changes the style of presentation to suit its reader, for example. A computer provides the most immediate means to explore this goal. Currently, electronic books, whether represented on a computer or videodisc player, tend to mimic the mostly linear representation of information imposed by the paper medium. Considering only speed and cost of access, the present generation of electronic books and computer networks could begin to replace conventional books and libraries. However, electronic books have not yet demonstrated superior readability or flexibility for their readers.

Paper books are, by their physical nature, static stores of information. The information content may change, but corrections and new editions are infrequently published. The primary organization of the book is also fixed at the time it is published. The author of a textbook or novel typically writes in a linear, page-oriented order that may be alphabetical, chronological, geographical, or pedagogical (embodying a conceptual curriculum sequence) in its organization. Pieces of information are related to each other by their physical proximity in a paragraph, on a page, or on neighboring pages. A subject index provides access to parts of the book in some other order. A good teacher, a set of questions, or the authors can help provide connections and cross references to seemingly distinct sections and ideas; footnotes (and parenthetical remarks) refer to details of minor interest, references to figures and chapters lead to other pages, and

bibliographic citations point to other books. These secondary organizations transcend the physical order of information by making new connections, but they are more cumbersome to use than the primary organization: it is easier to read the next paragraph on a page than to access and read a different page or a different book.

Not all perspectives of a book are of equal merit. An essay on philosophy might be read from beginning to end, which is the author's perspective; it could also, however, be related to the author's other works, compared to works on the same topic by other authors, or interleaved with commentaries by critics and annotations by the student, examples of three alternate perspectives. The primary representation of the information should not blind the reader to other ways of seeing the information nor limit the paths to access it. A dynamic book could offer several curricular views of a subject, each suited to a particular learning style or audience. For example, similar information content could appear in the form of a game, experiment, or cartoon, and be used for an introduction, remediation, or review by individuals with different backgrounds.

Even on paper, there have already been a few books that provide multiple options for traversal. The *California Tree Finder* (Watts, 1963) helps its user identify trees by guiding him through a "decision tree" based on attributes of seeds and leaves (for example, "If the tree has needles or scale-like leaves, continue on this page; if the tree has ordinary leaves, go to page 26"). Children's stories such as the "Choose Your Own Adventure" series give the reader fixed choices that guide the development and ending of the possible story. The first-time reader of a dynamic novel may choose to follow the author's original version but may occasionally want to review the numerous characters already introduced when names and roles become too confused. On the other hand, the repeat reader or literary student may wish to see alternate interpretations of the work made possible by sorting *flashback sequences*, interspersing a critic's commentary, or presenting sequences of events from the point of view of different characters.

The choices of "natural" primary and secondary organizations that anticipate the expected uses of information introduce a strong bias into the form in which a book is published today. As unexpected uses evolve and related information is discovered, access to this information may be more difficult in its old form. Take an index, such as the yellow pages of the telephone book, as an example of evolving word usage. Should you look under Septic Tanks or Aerobic Treatment, under Airplane Skywriting or Advertising -- Aerial? The newspaper columnist Erma Bombeck (1981) expressed this problem well:

> Telephone books are like dictionaries -- if you know the answer before you look it up, you can eventually reaffirm what you thought you knew but weren't sure. But if you're searching for something you don't already know, your fingers could walk themselves to death.

In a dynamic book, the goal is to let the reader deal with the information on his own terms, with respect to his own information needs. Rather than being a forced march for the fingers, depending on your searching or "browsing" style, extracting information from a dynamic book should be more like a casual stroll or a flying leap.

When reading a paper book, if you follow the text to a footnote and then go to the appendix, or start with the subject index and try to keep track of the many places in the text to which you want to refer, you can rapidly run out of bookmarks, fingers and short-term memory. Leaving annotations in the book margins, highlighting with a yellow marker, bending page corners or using different colored bookmarks are ways to manage this information and add some structure to a book. In a dynamic book, too, this structure could be added. More significantly, this structure could become part of the accessible information. The reader's very sequence of search actions becomes information that is describable to the book. Not only should a dynamic book store a history of where the reader has already looked, but it should be capable of returning the reader to previous choice points along an exploratory path or suggesting places where he has not looked. So the patterns of search are themselves information, and should be viewable and modifiable to construct new patterns or descriptions. In a role analogous to that of a research librarian, a dynamic book could alert the reader to new information that is relevant to these patterns, or sift through old information as new patterns are specified.

In summary, a dynamic book is not only a new kind of container for information, but also a collection of methods for accessing this content through many forms or maps. It could aid the reader in searching or navigating through this collection of methods. These active qualities distinguish it from traditional and merely electronic information representations.

If this were a dynamic dissertation, you, as the reader, could adapt it to your style of reading and thinking, and discover more specifically which of the above is fact, research, or fancy and how it relates to what is to come. You could read it at increasing levels of detail: as a one-page abstract, a longer abstract, a journal article, or in its entirety, or to interact with the frozen figures and data tables. Assuming such a dynamic version could be produced, you would need the training and computer hardware to access it. Otherwise, it would have to be transformed, with much loss of structure and fluidity, into a paper representation. The immediate and explicit goal of this research, however, is not to design and disseminate a dynamic dissertation (though that is a long-range and implicit goal), but rather to look at the designs of a book used by students to search for information. Which aspects of these books appear to help or hinder the search process?

The Search Process

In searching, as in navigation, there is the start of the journey, travel en route (including side trips), and arrival at the destination. For the same goal or destination, different individuals will have different starting points, different styles and modes of travel. Usually, a problem or question is posed by the student, teacher, or researcher that can be solved only by obtaining some information. Finding an answer will depend on the question's difficulty, the searcher's motivation, knowledge, and skills, and the help and information that is available.

Answering a question and solving a problem often proceed along the same lines. The original question or problem may be vague or complex. To find the answer, it may be necessary to

rephrase the original question and then to check if the answer solves both the rephrased and the original question. Perhaps the question can be broken up into more simple, manageable sub-questions, together with a plan for how to coordinate the partial answers.

The most difficult task is often finding the right question to ask.

There is no point in undertaking a journey if the destination is not recognizable, unless the trip is merely to scout or enjoy the terrain. Understanding a question implies being able to judge possible answers, by both correctness and appropriateness to the original purpose. Knowing about maps, weather en route, and the available modes of transportation can aid in planning a successful and economical trip. A question might be answered by retrieving a single fact from memory, reading a book or a library of books, consulting an expert, or building a research center. During the search, a different question may arise, and the destination may be changed accordingly. Landmarks along the path indicate the search direction and serve as benchmarks of progress. Mirages and sea monsters may appear; interpretation of the *I Ching* or of research results can be biased heavily towards what you would like to find. It is possible to travel in circles over old territory, to try radically different approaches, to reach impasses, dead ends, or the destination, or to simply give up.

In the world of information, to *understand* the question is to identify the significant ideas or concepts explicitly and implicitly mentioned. In order to access relevant resources, these concepts must be translated into a form suitable to the way the information is organized. A simple example is finding someone's number in a telephone book. The information is organized by long columns of last-name-first entries in alphabetical order, so you must translate the concept of finding the number into the form of finding the person's last name in the white pages. You can save time by looking at the names in the upper corners of pages rather than scanning every page in the telephone book in its entirety. (You had better know their first name, though, if you were looking in a Brazilian telephone directory, which is organized alphabetically by first name!) If the last name is a common one such as "Smith," you may also need the first name, middle initial, or even street information to disambiguate the different possibilities. If you know only their address or if the phone number is unlisted, other strategies may be necessary. A related example is trying to find a word in a dictionary if you have misspelled it, know only a synonym for it, or know only how it sounds.

Information has often been structured so as to reflect some underlying natural order or set of relationships among concepts, or to anticipate the most commonly asked questions. The white pages of a telephone directory are organized by last name to help people find numbers for individuals or businesses, address-order telephone books are organized by geographical area to help salesmen conveniently contact customers, and the yellow pages are organized by function to help people locate services. How well does your library's card catalog summarize a shelf of books? How well does a set of keywords or a subject index represent the content of a report or book? If there is mismatch between your question and the way the information is organized, you

must change your approach in order to access the information. A dynamic book should make it possible to adapt the information structure to your categories and preferred search strategies.

Once the information has been found, it can be used in many ways: for generating further questions; for solving a more complex problem; for reading, memorizing, or understanding an idea; for writing a paper; or for paraphrasing or explaining the important ideas to someone else. Not only is the information itself valuable, but the circuitous path by which you arrived there is just as valuable. The path can be followed again by you or someone else to access the same information more quickly another time, and it can also serve as a basis for describing information related to similar questions.

Answering Two History Questions

As an example, let us apply this search process to two questions from world history. The first question is "What are two important Cro-Magnon technological advances?" In an educational situation, this might be augmented by "Why were these two advances important? What two technological principles do they exhibit? Name two examples of modern technology that follow these principles." In any event, we must figure out how to answer the first question. Two of the significant concepts are related to words in the question: *Cro-Magnon people* and *technology*. Also included is the notion of *important advances* in technology, i.e., significant inventions, rather than minor improvements or uses.

There are several possible paths to the desired information in the information source at hand, a traditional history textbook, treated somewhat like a historical encyclopedia. Suppose one subject index entry with its associated page numbers is "Cro-Magnon humans, 10-13, 200, 211," and that those pages cover everything about Cro-Magnons; the heading "Prehistoric humans:Cro-Magnon, 10-13" refers to much of the same information. If we look under "Technology," we could use our prior knowledge of roughly when Cro-Magnons lived in order to select the heading "Technology:prehistoric, 5-6, 10-11." The heading "Prehistoric humans:tools of, 5-6, 10-11, 16" refers to many of the same pages and is helpful if we know that tools are realizations of technology. If we check the table of contents, we would find a chapter entitled "Prehistoric Peoples: Pioneers, Creators, Inventors," that covers pages 1-20; if we associate inventors with technology, we know this chapter will be useful. In any of these cases, the collection of pages is fairly small, so we can proceed by either starting to read in detail or by first skimming headings for references to the specific concepts of interest. For example, in the text proper there is a section with the heading "Cro-Magnon" that contains a further sub-section labeled "Tools." "Tools" contains several paragraphs about different tools used by the Cro-Magnons. The first paragraph mentions the use of knives and scrapers but does not stress their novelty or importance. The careful reader discovers in the later paragraphs that the Cro-Magnons were probably responsible for the spear-thrower, and the *burin*, a chisel-like tool-making tool.

The second example question is "Who are five heads of state who died before the age of 40?" If our subject index does not contain a list of important government figures under "Heads of State," or a convenient heading such as "Death:young leaders," we may have some trouble with this question. Perhaps we can think of an important head of state, then find his name in the index, and read to find out whether dates of birth and death put him in the desired category. Alternatively, we can start under "King" in the subject index (if that's a subject term), then try "Queen" and "Emperor," and perhaps leave "Presidents of the United States" out of our search if we know they are rarely that young when elected. As a last resort, we can go through the subject index and examine every person's name and refer to the text to see if he or she was a head of state who died young. If we know that England had a particularly bloody history, maybe that's the right place to start looking. If the author considered this information important, there might be tables of important leaders, vital statistics, and their significant accomplishments in prominent places in each chapter or unit. Timelines in each chapter could summarize important events including births and deaths of monarchs, and the time could be computed between these dates. Taking a different tack, we might look for appropriate causes of death for heads of state that could result in an early demise, such as "Assassination," "Revolution," or "Stress." Perhaps we have some situations in mind in which leaders are in jeopardy: for example, young leaders whose kingdoms are ruled by their guardians may have fatal "accidents" (and their parents may meet untimely ends as well); leaders of weak central governments surrounded by strong independent barons may be overthrown and killed.

The issue with respect to search is how to describe such situations or patterns of events in order to gain access to the information, without having to read the entire book, and preferably, having to read as little of it as necessary. A traditional subject index may be useless; a free-text search, such as for paragraphs containing the word "king" and suffix variants of "die" and "death," may fare better if one can find and use the same words that the author used. A more powerful approach might be to describe *events*. A history book could be considered as a network of events, bound together by common human participants, cause-effect relationships, time, geographical constraints, and "laws" of human behavior. To write a history book is to propose connections between these diverse events. To best search for information in such a book, one would describe the events directly rather than in terms of the commentary or map provided by the author. An even more powerful book might regard events as a simulation of history in which one could explore what happened and why, or what *else* could have happened.

There are some common tactics used in searches for answers when using a history book, encyclopedia, a library, or a telephone book. First, understand what the question is about by identifying the significant words in the question and transforming them, if necessary, into search terms or concepts. Second, pick a term and use some information structure, such as the table of contents, the subject index, the structure of the text, the text itself, or a librarian, to aid in finding information related to the term. When confronted with much information, scan or read in detail, or see if the information has additional levels of structure such as section headings in a chapter,

or sub-subject headings in a subject index. If possible, pick another term that is more specific, perhaps combining it with earlier terms. Try variations on the term, by changing its suffix, part of speech, or spelling. Use cross references, if the information structure contains them, such as "Farming -- see Agriculture," or invent synonyms.

To broaden our search, we may choose a related term or concept. The new term may be similar in a weak way (fire engines and Mars are both red) or in a stronger way (Argentina and Chile are neighboring countries in South America). We can relate by generalizing, as from the term "Cro-Magnon" to the more abstract concept, "Prehistoric." Or we can relate by specializing, as from "Forms of Government" to the more specific, yet still abstract term "Democracy" (and specialize further to examples of democratic governments). France and Europe and engines and automobiles each have a part-whole relationship; war and peace have a relationship of opposition. Luther could be considered to have a causal relationship with the Protestant Reformation. And there are many other associations that can be made between an attribute and a person (color of hair, spouse, food preferences), and a country or an event. Similar objects or events can be related by one or more attributes.

In order to answer questions that do not fit available information organizations, the information-seeker needs to have a broad perspective and flexibility in generating alternatives. A dynamic book can not only make other organizations and maps available and apparent to its reader, but it can also aid in the route-finding process.

An Itinerary

Chapter 1 has introduced the idea of a dynamic book and the process of searching for information. A navigational metaphor was used to suggest the interaction between traveler (the searcher), maps (information forms), and oceans (information content). Searching as an educational problem has been phrased in several ways. In summary, this dissertation is about designing and evaluating a dynamic book and examining the search strategies that students use to locate information. What are dynamic books? How can we characterize the search process? How do the maps and structure of information interact with a searcher?

Chapter 2 discusses previous work about information and the search process, with emphasis on those references relevant to the present experiment. Chapter 3 presents further background on information-retrieval systems and an experimental dynamic book. Chapter 4 describes an experiment done with eighth-grade students answering history questions of various difficulty by using both a paper book and either an electronic book or a dynamic electronic book. Chapter 5 provides details about the results of the experiment: individual search strategies and their interaction with book designs, and simple preference and performance comparisons. Finally, Chapter 6 summarizes this dissertation and plots a course for possible dynamic books of the future.

Chapter 2. Related Work

A Map

The purpose of the present chapter is to sail a course through material about the search process and aspects of information, and relate it to the present and future work on search in dynamic and traditional books. Buoys will mark some points of interest that lie nearby, yet off course. Because the journey is long, we will not spend too much time at any one place. There are many routes that could be taken to visit the same places. The itinerary chosen is one that mimics the search process itself, described in Chapter 1. Topics will be visited in the following sequence:

asking questions
planning a search strategy
accessing structured information
creating answers.

In finding the information to present here, questions such as "how do people look for information?," "what are the best information structures?," and "what dynamic books already exist?" were too general and vague as a means of accessing the relevant ideas mentioned in psychology, education, library science, computer science, and science fiction. Because this is a new area of research, our language must evolve to describe the key ideas adequately; because it spans many scientific sub-cultures, the words used to describe and classify existing work can differ widely. This makes the task of both finding and interrelating relevant work from different areas a difficult one. Crossover between fields is rare: computer scientists tend to refer to work of other computer scientists, psychologists to that of other psychologists. New studies surface constantly, sometimes in unpredictable places. What follows is a representative glimpse of this world.

Although all of the work described in this chapter is relevant to the search process and thus to the eventual design of dynamic books, an examination of three of these references and a combination of their salient attributes can approximate, in some sense, the subject of this dissertation. The other studies are important and provide a larger context for this and future work, but are peripheral to the issues emphasized in the present study. The work by Joyce and Joyce (1970) in the following section on "Asking Questions" provides an overall framework: elementary students seeking information in order to answer social studies questions. Bates (1979), in the section on "Planning a Search Strategy," suggests a set of tactics to be used in the search process. Some of these tactics can be applied to history questions (such as in the examples in Chapter 1) in the information environment of dynamic books (as described in Chapter 4). In the experiment of Rouse and Rouse (1981) that appears in the section about "Studying and Improving Structure," the books bear a similarity to those described in Chapter 4. Their subject groups used three versions of a book: "hardcopy" (i.e., paper), "softcopy" (i.e., an electronic simulation of paper), or "cued" (i.e., more of a dynamic book). The experimental design was also similar, although the experimental task did not focus on search.

Asking Questions

Studies of *inquiry activity* focus on learner characteristics for tasks that involve seeking out information in order to solve a problem. The study most relevant to the present experiment is reported by Joyce and Joyce (1969, 1970), who collected cultural studies material and structured it in a "data bank" of written and tape-recorded items. Elementary school students were responsible for gathering information from this data bank, organizing it and drawing conclusions. This approach to assessing creativity and encouraging inductive thinking was based on an earlier proposal by Karlins and Schroder (1967) for an "Inductive Teaching Program." In a similar study, Noy and Hunt (1972) explored how college students learn about a person (in this case, Sigmund Freud) through a biographical information system.

Students accessed the Joyces' data bank through a set of broad categories (for example, see Figure E-1 in Appendix E) via an adult intermediary (This adult intermediary used the category system to translate the student's question into a selection from the data bank). Several treatments were involved that varied the tasks to carry out, such as teaching another student or writing an essay, and the material a student saw, as selected by his own questions or by the questions of another student with whom he was paired. The Joyces called these methods for generating questions, *student-directed* and *system-directed*, respectively.

In a second study, the Joyces reorganized the materials to fit into the most-used categories, as determined by the questions students asked earlier; there were fewer categories but each contained more information. As an aptitude measure, they used "Conceptual Level" (CL), a measure of the student's flexibility in responding to complex, conflicting, and ambiguous situations. For example, in comparison to a low-CL student, a high-CL student might ask for more and different kinds of information and be able to generate more adjectives. At least on one output measure (number of themes generated), low-CL students did better with fewer categories, though there was little effect for high-CL students. It appeared that the tendency of high-CL students to access more categories, and thus more information, can be somewhat counterbalanced by giving low-CL students fewer categories with more information in each one. The question arose also of whether these elementary students could learn to use the category system directly themselves.

Although the present study does not share the Joyces' concerns with primary-source materials and student-seeking styles, their overall idea of students using an information source and accessing the categories directly to answer questions in social studies was a major influence on my early thinking about using dynamic books in education. The studies in the rest of this section are relevant to the search process and to the eventual use of dynamic books in education, but not to the present experiment.

Davis (1973) reviewed several studies of inquiry activity that attempted to correlate inquiry or seeking style with measures of problem-solving behavior, such as ability to sense or recognize

problems, formulate problems, and search for information. Shulman (1965) classified groups of teacher-trainees as having either a "dialectic" or "didactic" learning style, with the difference being that "operationally, dialectical seekers are more sensitive to potential problems, employ a wider range of information sources and exhibit a more flexible and reflective seeking pattern than do didactic seekers." He found correlations between these classifications and behavioral measures such as the number of materials attended to in an in-basket, number of categories used, and time. In an experiment by Allender (1969), students played the role of mayor of a city with a set of inquiry materials, cross-referenced by page and file number, representing the mayor's work, questions, files, and decisions. Allender found similar relationships between seeking style and problem-solving measures in younger students, and found also that students appeared to be intrinsically motivated by the task.

The training of scientific skills, one such being the skill of asking the right question to test a hypothesis, was investigated by Suchman (1960). He was interested in refining the questioning process to aid in solving problems or discovering physical principles. Using his approach, children learned to attack cause and effect problems in physics by asking questions from the teacher in order to gather data and to perform imaginary experiments. Suchman's proposed inquiry strategy was to classify the sample problem into some episodic categories, to determine the relevance of conditions, and finally to construct a theory.

An entire body of literature concerns improving comprehension by using the study technique of asking oneself questions before or after reading. In one study, Andre and Anderson (1978) found that students who were trained in generating comprehension questions did better than both those who had asked questions but were not trained, and those who did not ask questions; in addition, the technique appeared to be more effective for lower- than for higher-verbal-ability students.

Asking Someone Else a Question

Before embarking on a journey to reach a distant destination, one might consult a travel agent or a seasoned traveler who has already been there. One way to answer a question directly or to find a good approach is to consult either an expert in the field, an information-finding expert, or a research librarian. In the Joyces' study, adults referred students to relevant portions of some information source. Computer systems could fill this role also, depending on the degree to which they "understood" the question and could carry on a dialogue. Query languages for document and database systems will be described in a later section. There are systems that can understand subsets of natural language conversations about restricted domains and can carry out elementary inference in order to generate information related to explicitly stored facts. Language-understanding, however, is not an aspect of this study's dynamic history book.

Carbonell (1970) developed a computer-based tutor for South American geography. His SCHOLAR system recognized simple natural language student questions, and used various strategies for inferring answers that were not directly stored in the database. Information was

represented by a semantic network of relationships, given in the form (for example): Brazil is a country in South America, Rio de Janeiro is a city and state in Brazil, Portuguese is the major language of Brazil, Spanish is the language of most of South America, etc. If asked the question "what language is spoken in Rio de Janeiro?," the system should be able to reason from the "part-whole" relationship that it is the same language that is spoken in the country that contains this city. Normally, that might be Spanish, but because the country is Brazil, the language is Portuguese. In its guise as a tutor, a SCHOLAR-like system would be an invaluable part of a dynamic book. The student should be able to browse through the relationships or ask the tutor to make an appropriate next selection. Lukas, Collins, and Selfridge (1975) proposed the construction of a personal retrieval system that would assist in accessing a very large database intelligently. This system would model information about the user, the query at hand, and the database being accessed using semantic networks and artificial intelligence (AI) techniques.

Planning a Search Strategy

Before setting out on a journey, the experienced traveler will have considered in advance the different routes and maps available to him, and also have contingency plans ready for problematic situations, such as "what to do if lost." Surprisingly, there is not much in the literature that refers to information search strategies. Bates (1979) provided a good review of articles about the "reference process" (the term used in library science) and discussed "search tactics," which are a part of an overall strategy or plan. The tactics she defined are components of a model that could both facilitate searching and teach about it; the models of search strategy that she did not treat are those for idealizing and representing searching. She classified search tactics into four categories:

monitoring tactics: tactics to keep the search on track and efficient;

file structure tactics: techniques for threading one's way through the file structure of the information facility to desired file, source, or information within a source;

search formulation tactics: tactics to aid in the process of designing or redesigning the search formulation; and

term tactics: tactics to aid in the selection and revision of specific terms within the search formulation.

For example, "M1.Check" is a monitoring tactic "to review the original request and compare it to the current search topic to see that it is the same." For the earlier example history question about advances in Cro-Magnon technology, awareness of this tactic might prevent the searcher from pursuing the erroneous course of initially looking under Neanderthal technology. Of course, after the search has been unsuccessful in finding anything about Cro-Magnons, application of the "T3.Relate" term tactic would "move sideways hierarchically to a coordinate term" such as "Neanderthal." Table 2-1 summarizes Bates' information-search tactics and definitions.

Table 2-1
Summary of Information Search Tactics and Definitions (from Bates, 1979)

MONITORING TACTICS:

Tactics to keep the search on track and efficient.

M1.CHECK	To review the original request and compare it to the current search topic to see that it is the same.
M2.WEIGH	To make a cost-benefit assessment, at one or more points of the search, of current or anticipated actions.
M3.PATTERN	To make oneself aware of a search pattern, examine it, and redesign it if not maximally efficient or if out of date.
M4.CORRECT	To watch for and correct spelling and factual errors in one's search topic.
M5.RECORD	To keep track of trails one has followed and of desirable trails not followed up or not completed.

FILE STRUCTURE TACTICS:

Techniques for threading one's way through the file structure of the information facility to desired file, source, or information within source.

F1.BIBBLE	To look for a bibliography already prepared, before launching oneself into the effect of preparing one; more generally, to check to see if the search work one plans has already been done in a usable form by someone else.
F2.SELECT	To break complex search queries down into sub-problems and work on one problem at a time.
F3.SURVEY	To review, at each decision point of the search, the available options before selecting.
F4.CUT	When selecting among several ways to search a given query, to choose the option that cuts out, eliminates, the largest part of the search domain at once.
F5.STRETCH	To use a source for other than its intended purposes.
F6.SCAFFOLD	To design an auxiliary, indirect route through the information files and resources to reach the desired information.
F7.CLEAVE	To employ binary searching in locating an item in an ordered file.

SEARCH FORMULATION TACTICS:

Tactics to aid in the process of designing or redesigning the search formulation.

S1.SPECIFY	To search on terms that are as specific as the information desired.
S2.EXHAUST	To include most or all elements of the query in the initial search formulation; to add one or more of the query elements to an already prepared search formulation.
S3.REDUCE	To minimize the number of elements of the query in the initial search formulation; to subtract one or more of the query elements from an already-prepared search formulation.
S4.PARALLEL	To make the search formulation broad (or broader) by including synonyms or otherwise conceptually parallel terms.
S5.PINPOINT	To make the search formulation precise by minimizing (or reducing) the number of parallel terms, retaining the more perfectly descriptive terms.
S6.BLOCK	To reject, in the search formulation, items containing or indexed by certain term(s), even if it means losing some document sections of relevance.

TERM TACTICS:

Tactics to aid in the selection and revision of specific terms within the search formulation.

T1.SUPER	To move upward hierarchically to a broader (superordinate) term.
T2.SUB	To move downward hierarchically to a more specific (subordinate) term.
T3.RELATE	To move sideways hierarchically to a coordinate term.
T4.NEIGHBOR	To seek additional search terms by looking at neighboring terms, whether proximate alphabetically, by subject similarity, or otherwise.
T5.TRACE	To examine information already found in the search in order to find additional terms to be used in furthering the search.
T6.VARY	To alter or substitute one's search terms in any of several ways.
T7.FIX	To try alternate affixes, whether prefixes, suffixes, or infixes.
T8.REARRANGE	To reverse or rearrange the words in search terms in any or all reasonable orders.
T9.CONTRARY	To search for the term logically opposite from that describing the desired information.
T10.RESPELL	To search under a different spelling.
T11.RESPACE	To try spacing variants.

Although Bates' article is oriented toward the professional searcher in libraries or databases, a large subset of the tactics are applicable to the present experimental study. Some of the tactics are vaguely defined, with overlapping and missing functions, but they do provide a good starting point. By identifying proper use, misuse and lack of use of such tactics, we can hope to suggest improvements in student search-training. In addition, we might be able to design better information tools, such as dynamic books that incorporate and enhance the use of these tactics.

In a related article, Bates (1980) presented 17 "idea tactics" "to help generate new ideas or solutions to problems in information searching," and suggested another category of "question negotiation" tactics. Her idea tactics are drawn largely from the literature on problem-solving techniques, and provide a much larger context for searching than do the more focused search tactics presented earlier. Because they are more introspective that the better-defined search tactics, it may be harder to pinpoint their occurrence from external evidence. Table 2-2 summarizes and defines Bates' idea tactics.

A recent paper by Chapman (1981) reported on a Markovian analysis of on-line searching behavior. Her groups of searchers were distinguished by their experience with Lockheed's DIALOG system and by their training from either an experimental instructional system or another professional searcher. A zero-order analysis of state transitions, i.e., a frequency analysis, found significant differences between some of the groups with respect to the frequency of certain commands used. Patterns of command use were revealed in higher-order analyses, but these were not different between groups. Thus, individual commands corresponded roughly to some of Bates' tactics, and a sequence of commands could be thought of as a strategy. Representation of an expert searcher's strategy in this way could suggest patterns of tactics for training inexperienced searchers.

One way to represent information, its structure, and possible access paths, might be as a diagram containing points in an information space and in related index spaces. The search process, then, would be a journey through these spaces, constrained to follow certain routes defined by the topology of this space and by the application of appropriate tactics at each step. Using the navigational metaphor, the ship cannot take shortcuts through dry land; it should take advantage of favorable currents, tides, and winds. Crossing large expanses of unknown water may be rejected in favor of a longer but safer island-hopping route. Figure 2-1 diagrams some of the possible points and transitions that might be visited for the question about advances in Cro-Magnon technology used in Chapter 1. The left-hand side represents selected terms from the subject index; the right-hand side shows the primary order of the book, i.e., pages. Note that movements between these spaces can occur in both directions: one can go backward or forward in the page-order of the book, or think of a related subject term after reading a page, or examine the page references under a subject term. In addition, other transitions are not visible: one could choose a page number at the outset or skip an arbitrary number of pages; one could also use one subject entry to suggest another similar one, without going to the page space. For readability, subject terms are not presented alphabetically and not all connections between subject index and

Table 2-2
Summary of Idea Tactics and Definitions (from Bates, 1980)

IDEA TACTICS:

	Tactics to help generate new ideas or solutions to problems in information searching.
I1.THINK	To stop and think about the search and try to come up with new ideas for solving search difficulties.
I2.BRAINSTORM	To generate many ideas and to suspend critical reactions until the ideas are well-formed and can be fully evaluated.
I3.MEDITATE	To develop and utilize the skill of quickly achieving a state of mind in which rational and intuitive capacities work together in solving search problems.
I4.CONSULT	To ask a colleague for suggestions or information in dealing with a search.
I5.RESCUE	To check for possibly productive paths still untried, in an otherwise unproductive approach.
I6.WANDER	To move among one's resources, being receptive to alternative sources and new search ideas triggered by the materials that come into view.
I7.CATCH	To catch oneself in an unproductive search, to notice that a change in approach might be more productive.
I8.BREAK	To break a habitual search pattern, that is, put it aside temporarily, in order to take a search tactic more suited to the particular problem in question.
I9.BREACH	To breach the boundaries of one's region of search, to revise one's concept of the limits of the intellectual or physical territory in which one searches to respond to a query.
I10.NOTICE	To watch for clues that revise one's notions of the nature of the question or of the answering information.
I11.JOLT	To think "laterally" (after de Bono), to snap out of conventional thought patterns and redefine a problem in a dramatically different way.
I12.CHANGE	To change something, anything, in one's search behavior--to try a different source, a different term, a different subject field, etc.
I13.FOCUS	To look at the query more narrowly, in one or both of two senses: (1) to move from the whole query to a part of it or (2) to move from a broader to a narrower conceptualization of the query.
I14.DILATE	To look at the query more broadly, in one or both of two senses: (1) to move from a part of the query to the whole query or (2) to move from a narrower to a broader conceptualization of the query.
I15.SKIP	To shift laterally in one's view of the query, in one or both of two senses: (1) to move from searching one part of a complex, multipart query to another one or (2) to view the query from and search on another angle, that angle being neither broader or narrower but simply different.
I16.STOP	To cease searching temporarily on a problem and do something else.

QUESTION NEGOTIATION TACTICS:

	A not-yet-developed category that refers to tactics used both at the beginning of a search and during the search as the information specialist returns to the user for feedback on what has been found so far.
Q5.REFRAME	To examine implicit frame-of-reference information coming along with the user's query, to deal with it explicitly with the user, and to negotiate changes in the query to eliminate distortions.

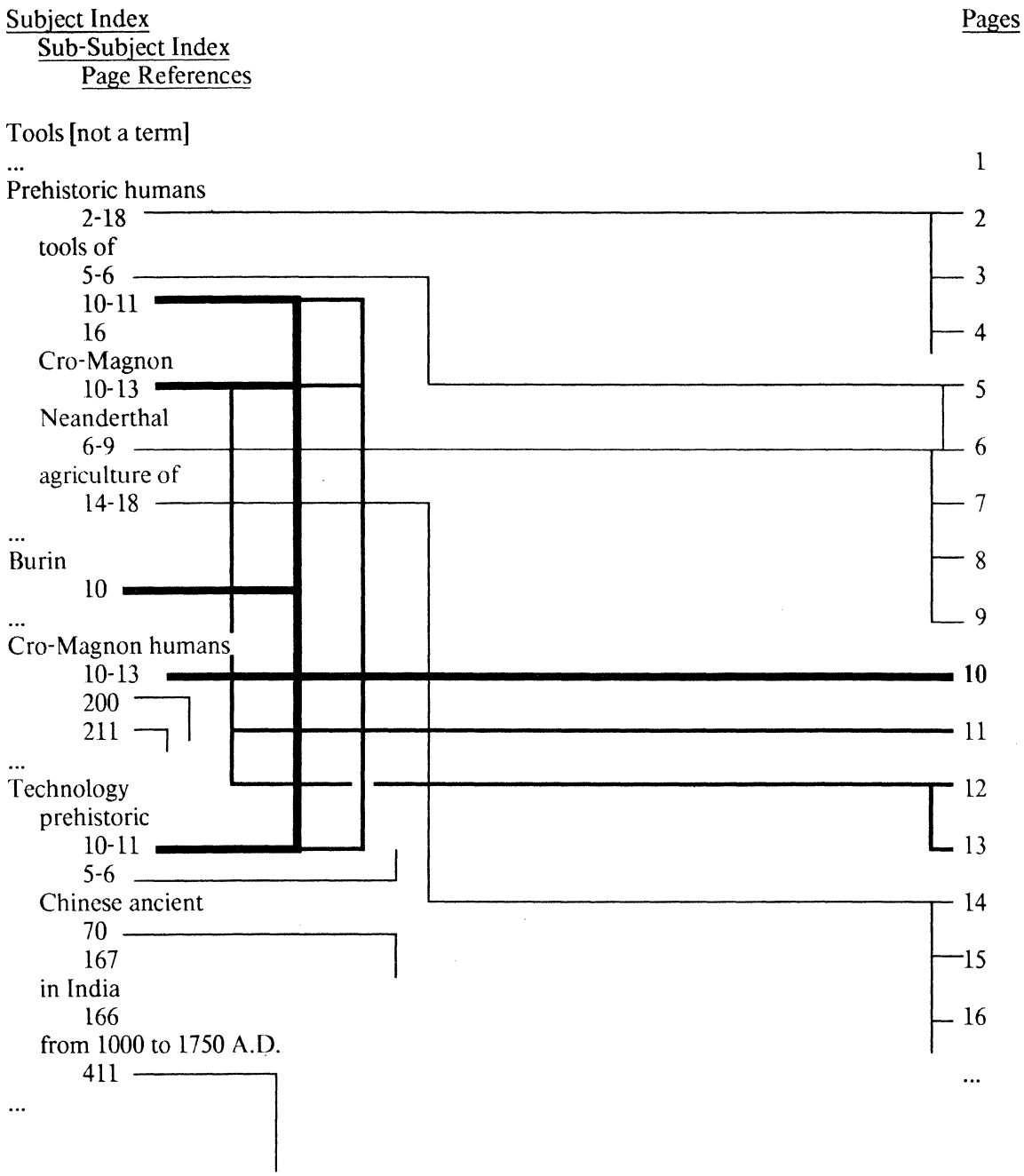

Figure 2-1. A Search Diagram for Sample Question about Cro-Magnon Technology

pages are shown. Line thickness shows degree of term relevance to the particular question, so that subject terms with the thickest lines refer most precisely to the location of the desired information. Deciding which line to follow or transition to try is choosing among tactics. If two subject headings were *Cro-Magon humans* and *Tools*, then application of the "F4.Cut" tactic would choose the heading referring to the smallest collection of pages. If *Tools* were not present, then "T1.Super" might suggest *Technology*. If the searcher found himself in the pages discussing Neanderthal tools, he could return to the subject index, or could continue reading for several more pages within the primary organization and find the section on Cro-Magnon tools.

The "best" strategy is likely to vary for each question, person, and information system. Strategies may be well-planned in advance or improvised as the situation develops. In both cases, memory of the question, perceptions of the information space, and knowledge of available tactics, especially those tactics applicable in the current situation, guide the course of a search. There will usually be several ways to get the same information, and which one is better depends on whether the prime goal is speed, simplicity, specificity, or generality of access. The same tactic may be a mistake or lead to a dead end for one question, but be successful for another. The same term may be used in different tactics; for example, Italy may be used in one tactic as a specific geographical entity in Europe, or in another as the cultural birthplace of the Renaissance. A tactic may be cumbersome to use in one information system and be more efficient in another. People with higher levels of experience, knowledge and skills might generate an even more general concept or related term than would the usual searcher. One information system might remind a student that certain avenues have not been explored, thus helping the student to take advantage of tactics, while another system may be so difficult and inconsistent to use that understanding the mechanics of its operation would overshadow thinking about tactics and even about the task at hand.

In other words, tactics are difficult to identify and to disambiguate in a search context, and may not correspond uniquely to a single command in a user interface. Introspective observations may be necessary also, especially to detect Idea Tactics. Most importantly, the lists of tactics do not suggest an order in which they should be applied. When the simple strategy of looking up an obvious subject term and following it to a single place in the text fails, for example, there is no order suggesting what the searcher should do next.

Ultimately, a comprehensive model of the search process is desirable. It should include the background of a searcher, kind of training received in using tactics and interfaces, the questions posed, and the structure and content of information sources used. It should explain or predict something about the sequence of a searcher's actions: given a point in the search, it should explain what happened and why, and what other actions could have been chosen. A larger model of learning could then ask how recall or transfer of requested or incidental information is affected by these search factors or related factors. The particular experiment reported here focused on a small area: observing existing search behavior and varying the interface for structured material to see the effect on choice of search tactics and overall search strategy. Other important educational

questions not directly addressed include: What would happen with students of different age or experience? How much additional training and practice is necessary to become an "expert?" What did students learn or remember from answering a series of history questions? How useful would a dynamic book be for other purposes?

Accessing Structured Information

Remembering or Inferring an Answer

One may recognize that the destination is close at hand, with no journey necessary. In the information world, this might be analogous to recalling a fact or making a simple inference without embarking on a complex search. Different experiments in the psychological literature have proposed that people might organize internally-stored information as a list of attributes, a hierarchy, or an associative network (see respectively, Smith, Shoben, and Rips (1974); Collins and Quillian (1969); and Anderson (1972)). An alternative view is that humans access the information in these ways, depending on the nature of the experimental task, though it may be stored in yet a different way; according to this view, the information is structured at retrieval rather than at encoding time. Williams and Hollan (1980) looked at how several subjects retrieved the names of high school classmates. Because this was information that was buried in "very long term memory," subjects used various strategies such as sequencing through names by letter of the alphabet, and associating people with activities, classes, or buildings.

Such psychological studies are important not only in examining the retrieval of humanly stored information, but also in the context of asking more general questions such as how appropriate internal organizations can be created, how existing organizations, both internal and external (i.e., indexes), can be used together to search for information, and whether there is an organization for search strategies. The first question, that of creating internal organizations, will be looked at in a later section on studying structure; the others will remain unanswered, at least for now. In the area of creating information, Resnick (1981) reviewed the literature on inference in reading comprehension and summarizes findings that "make it clear that inferences beyond the explicit information in the text are a normal part of the reading process." However, whether these inferences occur at the time of initial reading or at recall has not been clearly established. Both approaches are being explored also in the area of artifical intelligence.

Categories and Language

After starting a journey, one may use a map to identify one's location based on local landmarks; and one may employ a phrase book or interpreter to converse with the local inhabitants. Humans make assumptions about the correspondence of symbols and words to real objects or groups of objects. Literature on the formation and use of concepts and categories provides a complex developmental view of the ways that people organize the world around them. This literature lies at a level too fundamental for the present discussion, yet it is important to keep in mind as we discuss the representation of knowledge both for learning and searching in future dynamic books.

Psychological studies can help in deciding how to design good indexes or effective data models and query languages, i.e., how classes of objects and their attributes should be described, whether as lists, hierarchies, networks, or tables. The later section on query languages describes several such studies about the organization of information.

Bruner, Goodnow, and Austin (1956) explored the cognitive and linguistic evolution of concepts from egocentric and concrete to those more objectively based on function and multiple attributes. In a similar study of concept formation, Vygotsky (1962) examined the progression of concept "complexes," though from the point of view that speech and thought have different genetic roots. Markman, Horton, and McLanahan (1980) discussed the distortion of "class inclusion relations (e.g., the relation of oaks to trees) into the part-whole structure of collections (e.g., the relation of oaks to a forest)," and claim that this indicates that the latter relationship (part-whole) "is simpler to establish and maintain than the structure of inclusion."

The recent literature on the categorization of natural objects was reviewed by Mervis and Rosch (1981). They briefly outlined the history of thinking with many views about objects, their qualities, and of peoples' ideas about them. In British empiricism, for example,

> the ideas that people have of objects (concepts) consist of an intension (meaning) and an extension (the objects in the class). The intension is a specification of those qualities that a thing must have to be a member of the class; the extension consists of things that have those qualities. Thus, qualities (attributes) connect concepts to the world.

They also described classical concept formation experiments in which the passive and gradual learning of common elements was emphasized. Research after the time of Bruner "concentrated on subjects' active hypothesis-testing in the learning of relevant features and the logical rules combining them." Influenced by other subject disciplines such as anthropology and artificial intelligence, current research is raising such issues as the arbitrariness of categories, equivalence of category members, determinacy of category membership and representation, the nature of abstraction, the decomposability of categories into elements, and the nature of attributes.

At a very basic level, what we consider to be the information itself, which contains an ordered sequence of symbols in some language, is only a representation of some "fact," idea, inference, opinion or experience -- there is some distance between that information and the "truth" of what we perceive, know or experience and wish to communicate to others. Information, whether it is represented as poetry or scientific observations, may change as it is communicated, translated, or interpreted. Too, there is the problem that the symbol or summary may be mistaken for whatever it represents. In the general semantics tradition, Bois (1966) points at imprecise language and classification practices as the cause of ambiguous and erroneous communication of information. His map metaphor (after Korzybski) aptly characterizes these problems:

> the map is not the territory
> the map does not represent all the territory
> the map is not a map of the territory
> but a map of the mapper himself in interaction with the territory.

In a way analogous to the ontogeny of concept formation studied by Bruner and Vygotsky, Bois traces the phylogeny of mental models of Western man from the subjective and isolated evaluations of experience, to the classification of objects as static qualities, to relationships between dynamic objects, to uncertain postulates about the world including the role of the observer and his symbols, back to a subjective experience of the world that is unifying and almost mystical. In considering the design goal that dynamic books should provide "multiple points of view," Bois' book provides a very general and inspirational vision of what this goal implies.

Maps and Indexes

The words of a language are an approximation of information. There are also approximations involved at a higher level: the categories used to classify the meanings of the words; organizations to bring together related pieces of information; and summaries to emphasize what is considered important. For example, subject terms in a book index, card catalog, or an information retrieval system are categories; the alphabet, footnotes, and geographical relationships provide organization; and survey articles and section headings are summaries. These indexes and maps lie some distance from the original information. Of course, although a map is only an approximation, it may be good enough to help us reach our destination, so let us not fall into epistemological despair. Both education and language are based upon the assumption that the information representing our experience of the world can be organized and communicated successfully to others. Categories, comparisons, rules and theories emphasize certain similarities, differences, and other relationships among ideas or objects, and for that reason are powerful operations on information. Yet a category or stereotype is not the same as a set of individuals or ideas; a theory or generalization is not the same as a collection of observations; words in a language are not the same as the concepts for which they stand. We may use a map to guide our journey, but if we ignore or misinterpret the scale, we may never arrive at our destination.

These guides to finding information are, of course, information themselves. In a science fiction short story, Draper (1977) extrapolated the indexing problem to its logical conclusion, and indicated the "true purpose of education":

> These were the innocent days before the problem became acute. Later, Index runs were collected in Files, and Files in Catalogs -- so that, for example, $C^3F^5I^4$ meant that you wanted an Index to Indexes to Indexes to Indexes which was to be found in a certain File of Files of Files of Files of Files, which in turn was contained in a Catalog of Catalogs of Catalogs. Of course, actual numbers were much greater. This structure grew exponentially. The process of education consisted solely in learning how to tap the Rx for knowledge when needed. The position was well put indeed in a famous speech by Jzbl to the graduates of the Central Saturnian University, when he said that it was a source of great pride to him that although hardly anybody knew anything any longer, everybody now knew how to find out everything.

The book used in the present experiment has a simple subject index, but with provisions for quickly accessing it and searching it in non-alphabetic ways. Future dynamic books should have many possible maps and indexes for flexible access. The remainder of this section mentions what

is involved in building an index, some traditional index forms, and methods for measuring effectiveness.

Many of the techniques involved in constructing indexes and thesauri were discussed by Soergel (1974). The generation of useful indexing terms is related to the earlier work pursued by Bruner and others. "Determining the semantic factors of a compound concept has to be done in a pragmatic way by applying common sense. Theories of semantic factoring are difficult; they would be connected to theories of definition and theories of concept formation, especially of the formation of concepts in science." He continued with a list of questions that might be useful for semantic factoring. These are shown in Figure 2-2. Although these were intended for the design of indexes, they could also be usefully applied as tactics by a searcher to generate related concepts or terms, since these provide some additional "term tactics" to Bates' earlier list.

Of which class is it (the concept) a member or a subclass?
(distinguishing features may then be elicited by use of the other questions)
From what is it a part?
What is it made from?
What are its distinctive properties?
What is it capable of?
Is it or is it not accompanied by something else or accompanying something else?
Is it in a specific state, condition, or circumstance? Is it in a specific environment?
Does it determine, cause, influence, produce, act upon something else?
Is it determined, caused, influenced, produced by something else?
Has it a specific purpose, is it a means or instrument to achieve something else?
Is it a goal or end achieved or to be achieved by something else?
Is it a theory of something or an aspect of looking at something?
Is it looked at under a specific aspect or viewpoint?

Figure 2-2. Questions Useful for Semantic Factoring (from Soergel, 1974)

Some common indexing approaches involve constructing concept hierarchies from a fixed vocabulary of words, and representing titles several places in an alphabetical index, with each significant title word accessible alphabetically. Some examples of these and other indexes are given in Appendix E. For comparison purposes, several subject areas are presented in the appendix with several indexes referring to each: hunting and gathering as referenced by Joyces' categories and the historical presentation from the *Propaedia* of the *Encyclopaedia Britannica*; a segment of Sumerian history as represented by the *Propaedia* and by the table of contents and heading structure of *Our Common Heritage: A World History*; and the controlled vocabulary and concept structure for photography as defined by the *NASA Thesaurus*, *INSPEC Thesaurus*, *Thesaurus of ERIC Descriptors* and *Library of Congress Subject Headings*. Differences between the indexes are obvious in the choice of vocabulary, the number of levels of detail or depth of hierarchy, and the number of details or terms at a given level. Although each database is different in what it contains and how it is accessed, might it be possible to construct a single index that could be used for each example, e.g., a single world history index?

Keen (1977) proposed psycholinguistic research into the area of the intelligibility and comprehension of index entries that refer to documents but do not usually include the title or

abstract. "In linguistic terms the problem appears to be one of the comprehension of surface structures that are not usually very sentence-like in a situation akin to reading, but not one where speaking or listening are involved." Important words or unimportant words may be deleted, and spatial layout varied to emphasize other words. A related issue, one of "relevance prediction," would be important in deciding whether a given index entry was worth pursuing further, especially if the document was not immediately available for detailed examination. Keen's initial results, as reviewed by Roberts (1979), were fairly disappointing concerning index entry formats.

In the domain of library science, Bennion (1980) compared the subject indexing of two encyclopedias by collecting statistics on the success and failures of searchers in looking for the location of excerpted sections. This differed in three ways from other typical library studies: first, the searcher knew that the information existed; second, a sample of text, rather than a query, was used to guide retrieval, which thus eliminated the need to judge whether the resulting passage was "relevant" or not; third, he proposed a measure of subject indexes based on actual information retrieval performance rather than static measures such as index length, scope and depth of coverage. Traditionally, "recall and precision are direct performance measures that describe, respectively, the ability of the system to find documents that are relevant to specific inquires and to exclude documents not relevant to the inquiries." He suggested an informal definition of recall that measures the generating of index entries from the text itself; similarly, precision could be determined by going in the other direction, from the index to the text. Library students searched for articles in the *Great Soviet Encyclopedia* (GSE) using its subject index, and in the *Encyclopaedia Britannica* (EB) using the alphabetical subject arrangement of articles within the *Macropaedia*, or using the *Propaedia* or *Micropaedia* as indexes. The GSE was found to be superior to the EB with respect to both recovery (ratio of successful searches for a passage to the number of both successful and unsuccessful searches) and discrimination (ratio of successful lookups to total lookups).

Bates (1977) tested the subject indexing scheme of the Library of Congress (LC) used for library book catalogs (for example, see Figure E-6). Bates' scheme was similar to Bennion's later scheme: students generated subject headings after reading a book abstract in order to describe another similar book that they might search for (in contrast to one that they might catalog). This is related also to psychological work by Williams (1981) on retrieval by instantiation -- using an example rather than a generalization to initiate and guide the search. Searches done in psychology and economics by library and non-library students pointed out many problems with the current, inconsistent LC approach, designed in earlier, simpler times.

Query Languages

In general, a query language is any style of communication that can describe or specify what one is seeking. When interacting with another human or with an advanced computer system, the language for asking questions could be one's native language, including sounds, written symbols, gestures and facial expressions. A more specific connotation of query language is the symbolic

language used for retrieving information from some computer-based information system. Ideally, it should be as close as possible to the language used to store or represent information. For example, in English, declarative and interrogative voice have minor differences in word order, voice intonation, and word substitution for unknowns (i.e., "who" for a proper noun like "John"). The fact that a query language is different from natural language does not necessarily imply that it is better at describing things -- only that it is easy to implement, meshes well with some representation of data, or expresses certain questions succinctly, generally, or unambiguously.

Two styles of description are recognizable in the use of query languages; these mimic the intensional and extensional views of concepts. In talking about chairs, a person could use the Platonic concept of the ideal chair -- "chair-ness" -- or some set of representative chairs with constraints about how the desired chair can differ from these prototypes. In other words, the description can be general or specific, can be in terms of the class of objects or similar examples. If one is familiar with a concept structure, such as expressed in some of the example indexes in Appendix E, one can describe a complicated concept in some query language without looking at the resulting instances until the very end. On the other hand, one may have a concrete instance in mind (for example, Joyce's article) and would like to find similar instances (other studies of students accessing databases). By examining the instance, its location in some concept space, and its attributes, one can begin to define a pattern iteratively for similar instances of interest. Of course, these styles are not mutually exclusive and a user can employ both in searching for information, starting from the general, going to specific examples, and using these to formulate slightly different generalizations. However, query languages have supported the second style only indirectly because the user must perform some abstraction on the example rather than continue describing in terms of the example. Work in the direction of description in terms of prototypes has been done by Winston (1970), Williams (1981), Tou (1982), and Borning (1981).

Different user interfaces can be used to express the same ideas in a query language. In some sense, there are at least two query languages at work: the language and interface with which the user interacts, and the language expression that the system later interprets, possibly after transforming the original expression. A Boolean or relational expression can be represented in terms of a linear syntax like predicate calculus or a programming language, or it can appear as a two-dimensional collection of labeled forms; many attributes can be specified and combined at once in a parallel fashion. One might focus on a single attribute, and select values by recognition and selection from a list rather than by recalling and typing a term in a simple relational expression. This difference is analogous to that between ordering from a menu in a restaurant and asking the head waiter if the restaurant serves your favorite dish. Multiple attributes or a concept hierarchy could be displayed as a decision tree, with successive attributes selected in a sequential manner.

Studies of query languages tend to concentrate on a single model (e.g., relational) and focus on the difficulties of translating English queries into query-language form, mostly from the point of view of evaluating and improving specific languages. Reisner (1981) surveyed this area. The

experiments cited involved off-line tasks (as opposed to interactive computer use) and did not include the process notions of search strategy, such as what the user should do if his query failed in some way. The present dynamic book has a simple query language, i.e., menu selection and some pattern matching. However, later dynamic books should implement query languages that permit use of a subset for simple access as well as the entire language for more complex descriptions. Related work by Brosey and Schneiderman (1978) and Durding, Becker, and Gould (1977) addressed the more general problem of data model effectiveness by comparing subject performance on the tasks of classifying and accessing information represented by relational tables, networks and hierarchical trees.

Question-answering systems in artificial intelligence research include both a representation of some knowledge and a collection of reasoning procedures. Carbonell's (1970) geography tutor was built on top of such a foundation. Walker (1981) reviewed the past and potential contributions of artificial intelligence to organizing and accessing information. The MYCIN system (Shortliffe, 1976) incorporated decision rules obtained from human experts and then aided doctors in answering the questions of the form "what disease does this patient probably have?" and "what is the best course of treatment?" Winograd (1971) produced a landmark system that understood a subset of English in order to carry out manipulations in a small artificial "world" of blocks and boxes, and to answer questions about the state of this world. Lehnert (1978) looked in more detail at the process of answering questions, with primary emphasis on what would be involved in writing a natural language understanding system: she considered not only lexical manipulation of surface structure but also cognitive manipulation of the underlying conceptual information. If a dynamic book is to deal more competently with free-form text or to carry on a "natural" query dialog with its user, there are many issues involving the conventions of conversation, ambiguity, and contextual references, that must be addressed. If it is to be able to create or infer information for its reader, the original information must be represented conceptually as meanings rather than just as words.

For document-oriented (as opposed to record-oriented) systems, Atherton (1979) compared the effectiveness of free-text and controlled vocabulary searching for the ERIC database. She noted that different results are possible for the same search (a confusing state of affairs stemming from the variety of searchable and printable formats of ERIC records). Her survey included users of different retrieval systems, and showed the results of six different search queries. She reviewed previous retrieval effectiveness studies that addressed the question of the perceived advantages and costs of free-text searching, and that examined the subject areas where free-text differed in effectiveness from the controlled vocabulary approach.

Thompson (1971) constructed an early graphical system for displaying and accessing the multiple levels of a hierarchical index. He argued that this kind of format simplifies the process of query formulation because it shows the user the system's highly structured index space rather than leaving it to the user's guess-work or an off-line thesaurus. He also claimed that hierarchies are a natural way of representing knowledge, and Boolean expressions involving AND and OR can be

simply represented by horizontal and vertical selections, respectively, in a hierarchical decision tree. This approach of displaying multiple hierarchical levels at once is similar to the one used in the Findit database browsers that will be described in Chapter 3. It is different, though, from the style adopted in the ZOG system (Robertson, McCracken, and Newell, 1981) for moving through a large network of information. Each ZOG frame represents a node in a network (not necessarily hierarchical), and contains text, along with a menu of options; the options can be selected by touching the screen. Frames can be accessed by selecting one of the options, or by specifying a parameterized search. As a new frame is selected, the old one disappears, thus requiring the user to either remember or later ask the system where he has been. Such menu-driven, hierarchical systems appear easy for a novice to learn; however, Mantei (1981) is currently exploring the issue of how people get lost in such a network.

Studying and Improving Structure

A variety of studies examine the learning and recall of textual material as a function of the organization of the material. Explicit learning and recall are not involved in the present experiment. The studies are included here, however, because they deal with the "structure" in information, and future dynamic books will be used for other learning purposes besides searching. Additional references to structured information in computer database systems will appear in Chapter 3. Recent work in instructional psychology, especially reading comprehension, was reviewed by Resnick (1981). Both a reader's prior knowledge (e.g., a schema, framework, or set of expectations) and the organizational information in the text itself (e.g., advance organizers, summaries, questions) interact to help students recognize what is important and integrate it into their knowledge structure. From the viewpoint of the search process, an acceptable outcome of reading text and pictures can be the judgment of whether the material is pertinent to the immediate search topic, whether it is irrelevant, or whether it contains possible clues for other places to look. Research similar to that discussed below on learning could examine the interaction of prior knowledge and information structure on searching.

Dee-Lucas and DiVesta (1980) summarized two research approaches in the area of learning from text.

> Several methods have been used to either explicitly or indirectly manipulate readers' processing activities and thus influence learning from text. One approach is to provide the reader with information about the text's structure or organization in the form of outlines, headings, or topic sentences. As organizational aids, these generic classifiers are designed to facilitate recall by making the relationships among various informational units of the text explicit, such that the superordinate ideas can be used to facilitate recall of the subordinate information. Another approach requires the reader to perform some operation on the text, such as summarizing, outlining, underlining, or answering questions. These tasks induce the reader to process a subset of the text information more thoroughly and thereby activate related prior knowledge as an aid to learning.

In other words, the material is structured for or by the reader. In their study, they combined these two approaches; subjects read material, using one of four organizational contexts (topic

sentences, headings, related factual sentences, and unrelated sentences) provided by the experimenter or subjects generated information to complete the organizations. Not surprisingly, Dee-Lucas and DiVesta found effects that varied for the organizational context, processing task (read or generate), and the type of test (recall or recognition) used. The generating tasks caused "a focusing of attention, probably resulting in a subset of the text being learned very well (intentional learning) but at the expense of other (incidental) information that would ordinarily be encoded by the skilled reader when no orienting task was presented." Similarly, "variations in context direct the learners to attend to different types and quantities of information."

The notion of advance organizers was originally introduced by Ausubel (1960). Advance organizers are written at a higher level of generality than is the material, while overviews or summaries are written at the same level of abstraction as is the material. In particular, advance organizers do not necessarily contain any content of the material to be learned but attempt to provide a framework for learning that can be connected to previous knowledge. In this sense, they could also be used in the search process because they could help in connecting together diverse information. An advance organizer for studying this dissertation, for instance, might tell the reader to consider navigation as a metaphor for searching. The "retrieval" that is mentioned in testing the effectiveness of advance organizers or any organizational aid is retrieval from memory after reading the material, and not retrieval from the source material itself. Although the purpose of advance organizers appears to be different from that of external structures, i.e., recall vs. search, there may be some useful cross-fertilization between these areas of research.

Although advance organizers seem like a simple and powerful idea, there have been many conflicting studies and much controversy. For example, Barnes and Clawson (1975) examined the previous work that had been done (32 studies) and found no consistent pattern of results when they asked the very broad question: "Do advance organizers facilitate learning?" Mayer (1979) helped in clearing up some of the reasons for past confusion by rephrasing this question to "Under what conditions do advance organizers facilitate learning?" He claimed that advance organizers are most effective when the material is unfamiliar, technical, or otherwise difficult for learners to relate to their existing knowledge; they may not help in other situations. When advance organizers are used, the key ideas should be well "conceptually anchored" to existing knowledge, resulting in better retention and transfer. Minor details may be lost (the process of "obliterative subsumption") and should not be weighted as much as the important ideas. Lastly, many studies seem to lack adequate experimental control: control groups did not receive adequate additional materials to compensate for the organizer material presented to the experimental group.

Issues of *Journal of Educational Psychology*, *Journal of Experimental Psychology: Human Learning and Memory*, and *Review of Educational Research* contain numerous other articles about learning objectives, advance organizers, questions asked during or immediately after reading, pictures as organizational aids or as distractors in reading, and hierarchical structure. The general consensus is that the structures provided by the text itself, or by the tasks to be performed, affect the learning and recall of information. In the experiment described in Chapter 4, the task was to

search for information in order to answer a question -- no memory task was involved. The following study by Frase and Silbiger looked at search as an orienting task and its effect on memory.

The retrieval process involved in extracting information from sentences in a passage of text was examined by Frase and Silbiger (1970). Subjects, with a particular complex question in mind, read paragraphs that listed attributes of planets and then later recalled or recognized some of the information. Distributing the related information throughout a text imposed a barrier that subjects had to overcome by establishing criteria for detecting relationships among separated sentences. "Making simple discriminations among text items produced learning changes especially on items for which information had to be located (criterion items), but also on items that would result in a decision to reject a sentence (compared items)." Students who read the well-organized text (one paragraph per planet) did not take as long to answer the question, but did not do as well as the other groups on later recalling and recognizing planet names. The other groups had to search the text to locate attributes about a planet keyed by its name; although this took longer, it appeared that "the search task produced incidental learning of the names which would only be useful in rejecting irrelevant sentences."

Frase and Schwartz (1979) studied the role of segmenting and indenting text to isolate meaningful components of sentences (e.g., causes and effects, sequences of events), and thus to increase comprehension. This was motivated by the desire to reduce the complexity of technical manuals. After testing different formats in five experiments, they found a faster response time in answering questions when text was both segmented into phrases and spatially organized (indented), though segmentation seemed to be the more important factor. Again, there are implications here for the design of better books, both paper and dynamic, especially at the level of passages of text. Given an appropriate representation for the important ideas, a dynamic book should make it easy to change the typographic and graphic layout of a page for the demands of the task or reader. It may be also possible to generate automatically an appropriate layout. The present experiment makes some changes in the layout of a textbook, but does not rewrite it.

In addition, future books can be improved along some other dimensions, such as choice of headings. Swarts, Flower, and Hayes (1980) tested comprehension of different versions of a life insurance policy. They assumed that the reader's goal was not to absorb the information so much as to find specific information in order to act. In this way, it is different from the work on advance organizers, where headings provide structure for learning. However, it is similar to the present experiment where students may use chapter, section and sub-section headings as signposts for locating information. The experimenters found that accurate headings were better than vague or erroneous headings and that "clear prose generally outweighs misleading headings" with respect to answering questions correctly. They suggested improving reference materials by techniques such as providing scenarios, and providing headings that allow readers to predict the content of the section that follows.

Not only headings, but also entire textbooks can be poorly written. Anderson, Armbruster, and Kantor (1980) argued this after informally studying two samples of expository prose from sixth-grade textbooks and comparing passages on the basis of structure, unity, coherence, and audience appropriateness. They did not test different versions on sixth graders, but described the likely problems students would encounter in reading and understanding the text.

As a means of improving written materials, whether on paper or on a computer, Horn (1976) described a technique he calls "information mapping," a set of procedures for adding structure to documents. For example, by identifying and labeling definitions, objectives, examples, and procedures in otherwise unstructured prose, he claimed to improve the utility of training and reference manuals. Of course, such techniques as improving headings can make a book (dynamic or not) more readable by identifying sections accurately so that their usefulness can be more quickly judged, but there are no studies using his specific technique to support these claims.

Wendt (1979) discussed the redesign of textbooks to increase legibility by changing the number of columns on a page, the spacing between words to emphasize syntactic structure, and the spatial layout of different levels of detail. This bears some similarity to the work of Frase and Schwartz (1979) discussed earlier. Four versions of a physics textbook were tested with German secondary school students. Although the analysis of variance was complicated by class effects, there were small differences between the textbooks with respect to reading time and achievement test scores. After some disclaimers about lack of longer training with the different formats, they cautiously recommended that their most experimental format, which would require the most rewriting and restructuring, be used for writing and designing new textbooks.

A book by Hartley (1978), about the typographical issues relating to the improved presentation of instructional text, was reviewed by Kinross (1979) and the review rebutted by Hartley (1979). Although the primary criterion is claimed to be clarity of presentation to aid the reader, in many cases, empirical studies of several formats showed no difference in ease of use. The secondary criteria were production time and costs, and visual preference by readers. The more basic recommendations about typography such as typeface, typesize, word-space, and line-space can be thought of as guidelines. However, decisions about showing structured information, such as whether one should emphasize with vertical space or with indentation, were less clear. Some of the earlier empirical work and most of these considerations will be important for dynamic books as well. Flexible layout will make it possible to do experimentation more easily, to discover how formats interact and under which conditions one format is better than another.

Rouse and Rouse (1980) compared the use of hardcopy versus computer-based aircraft operating manuals. There are difficulties with cross-referencing between multiple paper manuals, in keeping versions up to date, and in physically manipulating bulky information while trying to fly an airplane. In a small experiment involving three formats (hardcopy, softcopy, and cued), 17 emergency procedures for a Boeing 747, and random interruptions of the task, they "found that an on-line manual which provided considerable user assistance (cued) was superior to a hardcopy

manual in terms of both task completion time and errors. However, an on-line manual without user assistance (softcopy) was inferior to a hardcopy manual in terms of errors."

This experiment is a good example of how using a computer intelligently to represent or access a book (here, computer cueing helped the reader keep track of procedural steps even during interruptions) can be better than just an electronic version of a hardcopy book (softcopy). In this case, the cued manual was better than the hardcopy version also, despite the fact that more of a procedure fitted on a printed page than on the computer display. The emphasis in their experiment was on following complex procedures rather than on searching for information. A dynamic history textbook which is described in Chapter 3 provided both some of their "cueing" capability for managing information from multiple places, and improved subject access. With respect to experimental design, each person in their experiment used all three books; in the experiment in Chapter 4, students used only the paper book and either the electronic or dynamic book.

Creating Answers

Ultimately, the information we have found, whether in a book or from a computer system, must be read and understood if it is to remembered or communicated. Joyce and Joyce (1970) had students perform different "answering" tasks, such as teaching another student or writing an essay. Other experiments looked at simple recall or incidental learning. There may be additional transformations involved, such as graphing, sorting, summarizing, and changing of the information in order to emphasize certain goals or address different audiences. The important and broad areas of reading skills and technical, structured, and creative writing must be included to eventually make our map complete. Writing a dynamic essay that references dynamic books or creating a new dynamic book might require yet different skills.

This dissertation is a particular form of an answer to several questions about search and dynamic books: What are dynamic books? What is the search process? How does the structure of information and its maps interact with a searcher?

Chapter 3. Information Systems

> Ford handed the book to Arthur.
> "What is it?" asked Arthur.
> "*The Hitch Hiker's Guide to the Galaxy.* It's a sort of electronic book. It tells you everything you need to know about anything. That's it's job."
> Arthur turned it over nervously in his hands.
> "I like the cover," he said. "*Don't Panic.* It's the first helpful or intelligible thing anybody's said to me all day." (Adams, 1979)

This chapter will provide additional references and background about information systems: dynamic books and document-oriented and database systems. In particular, the dynamic book used in the present experiment (described in Chapter 4) will be explained in detail with examples of how its use might affect the user's search process.

It is unlikely that the amount of available information in the world will decrease (even though people may agree jokingly that 90% of the information in most fields is worthless, deciding which 90% to discard, edit, summarize, or archive would be difficult). Because information systems, already present in many homes, schools, and businesses, will become increasingly available, they are often touted as solutions. Predictions are commonplace, as exemplified by Joshua Lederberg's (Goodman, 1981): "Terminals of this kind and their searching capacities are going to give one access to the libraries of the world. The libraries of the world will be decentralized but available to anyone who has a terminal that can connect to the world's communication systems." Electronic libraries have the advantage of making more information directly available. However, availablity is not the same as accessibility. To be more useful than the paper and microfilm they replace, such systems must provide new information structures and search capabilities. Electronic systems can offer more powerful ways of sharing information: individuals can access the most up-to-date version or edition of a book (obviating the need for numerous copies of potentially obsolete material), and people with common interests can use the system to facilitate discussion. The real issue is not whether such information systems are inevitable or whether access will be fast and inexpensive, but rather whether these systems can be improved to increase the ways in which information can be located and manipulated.

Visions and Versions of Dynamic Books

Vannevar Bush (1945) wrote an article to inspire scientists to turn their peace-time attention to inventions for gaining some mastery over man's accumulated knowledge. Among other things, he envisioned a desk-sized information tool (a "Memex") that would be an electronic library and filing cabinet for helping scientists enter, sift through, classify and interconnect the information in what was considered even then to be a "growing mountain of research." This tool would allow a researcher to leave behind "trails" of associations to link similar pieces of information together in a network. Although his article is over 35 years old, there is yet no Memex on the market. A few systems, though, such as the research prototypes cited next, exhibit some of the Memex's dynamic characteristics.

For the last ten years, the Learning Research Group (now, the Software Concepts Group) at the Xerox Palo Alto Research Center (PARC) has had as its goal the development of a *Dynabook*, a personal computer the size of a notebook, and *Smalltalk*, a programming system for communicating with the Dynabook (Kay, 1969; Kay and Goldberg, 1977). Several predecessors to a Dynabook and several different designs of Smalltalk have been completed. The Dynabook-Smalltalk system is intended not only to be small and portable, but also to be as easy and natural to use as a book. It should handle its owner's many needs for manipulating dynamic information in diverse media: text, pictures, simulations, animation, and music.

Findit (Weyer and Kay, 1976) is an experimental system written in Smalltalk for editing, retrieving and storing documents. These documents can represent collections of data (e.g., records that represent telephone entries or article abstracts) or internally structured objects such as manuals or books. Some examples of these documents, in addition to a detailed description of the dynamic books to be used in this dissertation's experiment, will be given later in this chapter.

Smalltalk is an interactive, object-oriented language in which objects, the parts of the language, communicate with each other by means of sending messages. Classes are defined in order to group objects with common behavior. In this way, Smalltalk exhibits its ancestral ties to Simula (Birtwistle, Dahl, Myhrhaug, and Nygaard, 1973) and to the intensional view of objects of British empiricism discussed under categories in Chapter 2. The earliest versions of the Findit system were implemented in Smalltalk-72 (Goldberg and Kay, 1976); the current Findit system is written in Smalltalk-76 (Ingalls, 1978). The Smalltalk-80 system ("Smalltalk-80" is a trademark of Xerox Corporation) is the most recent version of the language. Because the language differences between Smalltalk-76 and -80 at the level of this dissertation's discussion are not great, and literature on earlier versions is hard to obtain and has few language details, the reader interested in Smalltalk should refer to the August 1981 issue of *Byte* magazine and to the forthcoming books on the Smalltalk-80 system (Goldberg, Robson and Ingalls, 1982).

Another effort in the direction of a Memex is the Spatial Data Management System (Negroponte, 1979). This system added personalization, sound synchronization, and spatial data access to traditional book-style access through the use of videodisc technology. One form of personalization is to present the material more succinctly to someone who has seen the material recently or who is an expert. (Too often the notion of *personal*, as in personal computer, is meant merely in the sense of ownership rather than in the wider sense of the system adapting to the individual.) By providing *Dataland*, a two-dimensional surface with data located in neighborhoods with landmarks, Negroponte imitated the spatial style of access that someone would use in finding items arranged on a desk or around a building. Dataland is a dynamic map, and users "fly" through information space, "hover" at different heights to vary the detail, and "land" to read.

Nelson (1970) criticized the educational system for compartmentalizing subject areas and for standardizing teaching sequences excessively; he also criticized computer-assisted instruction

systems for continuing the same tradition of external control of the student. He proposed a system for writing and perusing dynamic documents, for which he coined the term "hyper-media" to include text, pictures, animation, and close connectedness between different parts of the material. "Hypertext" could contain links to footnotes, comments, summaries, and other sources; "hypergrams" and "hypermaps" are dynamic pictures that could be magnified and animated. A link to another document, possibly seen as "Nelson, 1981, p. 32," could be immediately followed to the corresponding document. In traditional documents, the reader must first look up the reference alphabetically in the References or Bibliography located near the end of the document, obtain the book somewhere, and then turn to the appropriate place. In *Literary Machines*, Nelson (1981) summarized the progress toward these goals, discussed the problems of electronic publishing such as authorship and royalties, and promised that a "Xanadu" hypertext system would be available soon. Except for providing a simple category system and links within and between documents, he did not address the problem of searching for information.

Document-oriented Systems

Database systems span from document-oriented to more highly structured record-oriented systems. Documents typically have some limited external structure. This structure might consist, for example, of a title, an author, an abstract, and some keywords, followed by many paragraphs or pages of unstructured information. Unstructured information is presented in a linear, relatively unlabeled order. The systems discussed in this and the preceding sections can be described as document-oriented. Records, on the other hand, possess only labeled parts or fields that have highly constrained values such as names (including names of other records), numerical values, and dates. Typical record-oriented applications are payroll-processing and inventory control. The section on data models will provide further discussion of this more structured information.

The NLS system (Engelbart and English, 1968) developed at Stanford Research Institute (now, SRI International) implemented networks of dynamic documents, and introduced the "mouse," a pointing device analogous to a light pen for referring to points on the screen. Not only was NLS an advanced text-editing system, but users could add hierarchical structure to a document, and link it in a network to other documents. The user could view several documents on the screen at once, could control how many levels of structure to display, and could move quickly between levels of the document and follow cross references to other documents.

The Lockheed DIALOG system makes large document-oriented databases, such as patents and ERIC abstracts, available to a wide audience. Research librarians are its chief users. Documents can be retrieved by specific words from special fields, such as author or keyword, and the sets of references from a field can be combined with other sets from the same or different fields by Boolean operators: AND, OR, NOT. Any combination of words occurring in any of the fields, including the abstract itself, can be used to specify documents. This "free-text" search capability is one important step for query languages in the direction of accessing by means of the information itself rather than by some processed view of it, such as is required by keyword lists

or subject indexes. However, free-text search still depends on which words the author actually used. It may be necessary to specify several synonymous phrases ("sun-powered" or "solar"), a list of words ("religions" or "religious") or a pattern ("religio*", where "*" means match any suffix) to find the documents you want. Such free-text systems work best for specific, well-defined terms such as proper names or technical jargon. Words in common usage or with several meanings will usually have to be combined with other words in order to specify further the desired documents, so in some sense this is defining a "concept." Typical systems, such as DIALOG and LEXIS, allow combinations of phrases, with ellipsis (...) or variable-length word gaps. For example, to find out about religious wars, the query specifies that the words religion and war (and their variants) occur within the same sentence, say within 5 words of each other.

"Full-text" search systems, such as LEXIS by Mead Data Central, provide free-text access to entire documents, not just to their abstracts or selected fields. In this sense, they are much more document-oriented than the DIALOG system. Lawyers use LEXIS to search databases of court decisions; the NEXIS system, also by Mead, provides full-text access to *Newsweek*, *The Washington Post*, and other periodicals, both current and past issues. Rather than depending on headlines or a non-existent index, a full-text search for "gold" could reveal information about its price in the business section, discoveries of new deposits in the news section, its use in cookware in the gourmet section, and other miscellaneous mentions of it in cartoons, gossip columns, dental and jewelry advertisements, and the want-ads.

The SMART retrieval system (Salton, 1968) approaches free-text retrieval of documents differently. It can be thought of as a method of automatic indexing, with preference given to certain words that occur in the documents. It assumes a multidimensional document space whose dimensions are word stems (concepts) in which documents are assigned coordinates weighted by word frequency (a form of concept strength). In these terms, if the word "gold" occurs more than once in a given document, it will be assumed that this document is more useful than one in which it is mentioned only once, or in which it doesn't occur at all. On the other hand, if a word such as "computer" occurs numerous times in all of the documents of interest, it might be ignored because it does not discriminate between the different articles very well. The user of such a system can specify a request in free-text form, but can also assign weights (of relative importance) to the different terms, and thus build up a profile of the desired concept or document. Of course, this method still assumes that the user can discover an author's pattern of word usage.

The publishing industry has been examining the electronic dissemination of information (Dahlin, 1981) and wondering how it will affect the demand for traditional books and how new information markets will evolve. Teletext or videotext systems, such as Prestel (earlier called Viewdata) in Britain, can be accessed with technology that exists in most homes already: telephone and television. Movie schedules, restaurant reviews, and train timetables are available through a simple, sequential, hierarchical interface. Pemberton (1980), though, in examining the state-of-the-art for teletext and other similar systems, found it disappointing. Newspapers such as

the *San Francisco Examiner* can be read in an electronic form on your home computer terminal before the printed version arrives at your neighbor's door, but it can be accessed only through a flat table of contents (by selecting a number from a numerical list of standard features such as "5" for PAGE ONE, "52" for Arts reviews, or "28" for General (Sports)), and not by subject phrases or its content words.

The information provided by document-oriented systems, teletext systems and electronic books and newspapers may be generally useful. For these systems to be regarded as information "services," however, we must ask the important question of how well they serve the individual. In other words, how well does the form of presentation (e.g., Boolean expressions, free-text patterns, or hierarchical selection) mesh with a person's searching style? The answers (or lack of answers) to this question will influence the design of information systems in the coming years.

Information Access in Education

The use of databases for educational applications has been primarily in areas of research (ERIC and statistical analysis packages), school administration (classroom scheduling and attendance records), and some career counseling, but the cost and complexity of such systems has limited their use to adult individuals. The increasing availability of computers in the classroom and networks to connect them to databases should change this. The "data bank" of cultural materials used in the studies by Joyce and Joyce (1969, 1970) could easily have been implemented on a computer. Jackson (1975) discussed a simple database system for which elementary students collect information about themselves in tables, encode it, translate their questions into a simple query language, and generate reports. He claims that "children as young as nine years can go through the mechanics of designing a database and collecting the information." He gives no examples of students using the query or report language, noting that teaching about what information is worthwhile to extract and how to ask for and summarize it is a harder problem. Lewis and Tagg (1981) and Knox (1975) reported about similar database systems for educational applications.

Collins, Adams, and Pew (1978) explored some of the possibilities of using dynamic maps for asking questions and displaying information within the SCHOLAR system (Carbonell, 1970). They compared three groups of students using SCHOLAR with an on-line map (Map-Scholar), with an off-line labeled map, and with an off-line unlabeled map on tests of geographical knowledge. A "backtrace" of information about each tutorial interaction was stored as it occurred, preserving the type of question or activity presented to the student, and the student's responses and errors. Students in the Map-Scholar group did significantly better overall than students in the other groups, and the effect seemed tstrongest for location-oriented information.

Depending on the branching strategies built into the system, a computer-assisted instruction (CAI) system can be thought of as being a dynamic book and presenting a dynamic curriculum to each student. The "next" section or lesson may be fixed or it may be found by some function of the

student's ability as measured by the system over time. The course material may be stored in a one-dimensional sequence or in a complex semantic network accessible by many attributes of the material, such as student ability, concept prerequisites, or classification according to instructional style. In this sense, a CAI system (like most computer programs) uses a database, but the teaching program acts as an intermediary to control access to the information. Students generally do not have the chance to choose directly whether they want to review some earlier information, consult an on-line librarian or tutor, or skip ahead to a different lesson.

Database Systems and Data Models

The LEAP language (Feldman and Rovner, 1969) introduced powerful mechanisms for associating information in triples, and stating queries as incomplete triples to be matched. For example, if John's sister is Mary, then John is the *object*, sister is the *attribute*, and Mary is the *value*; object's attribute = value. You could then ask not only who John's sister is (John's sister = ?), and who has Mary as a sister (?'s sister = Mary), but also how John and Mary are related (John's ? = Mary), and even who is related to Mary in any way (?'s ? = Mary). The first kind of question can typically be answered by using record structures in many programming languages (e.g., Algol, Pascal) or by querying an object in Smalltalk. This is a straightforward operation if John is the name of a variable that refers to the record, or if the list of records is organized alphabetically by name (the object of the triple). The second kind of question, ?'s sister = Mary, can be answered by searching the list of objects for the value Mary. Of course, if the list is large, this can be time-consuming. Most information retrieval systems use indexes for faster access: for example, keeping a list of all sisters, and for each sister a list of siblings, i.e., Mary sister-of John, sister-of Jane. Inverting a relation in this way improves performance at the time the question is asked, but incurs some overhead in space and time when the information is originally stored or later updated, because analogous changes must be made to the *inversions* to keep them consistent with the primary information. (The white pages of a telephone book are a good example of the primary information, the yellow pages an example of a parallel copy or secondary ordering of some of the same information. When the address or telephone number of a business changes, it must be changed in both books.) "Who are Mary's brothers?" is a slightly more complicated question that requires rephrasing of the question as "of whom is Mary the sister, and which of these people are male?" or instructing the system about the attributes of and relationships between people so that it can make inferences.

Chamberlin (1976) provided an excellent tutorial covering the relational model of data, originally introduced by Codd (1970). Kim (1979) surveyed existing relational database systems. In the simplest view, information in a relation is represented as rows in a table, or a collection of "n-tuples." A simple example of a relation is the sister relation used above, [individual-name, sister-name]. *Individual-name* is the *primary key*, and the value of this key must uniquely identify an individual. Note that "John" is not a good choice for primary key -- he might be better identified as John Q. Smith or as the John Smith who was born at a certain time and location. *Sister-name* is a *secondary key* but its value does not have to be unique. For example, Mary can

be the sister of more than one person. Additionally, John can have more than one sister, which would result in a separate instance of this relation for each, [John, Mary], [John, Jane].

A strong advantage of the relational model is separation of the actual representation of relations and data from the query language and application programs. Queries may be stated in terms of "virtual relations" that are a particular constructed view of the actual data. For example, if the relations are [individual-name, sex] and [individual-name, sibling-name], a "sister" relation could be defined as siblings who are female, resulting in the same effect as the example above. Powerful mechanisms allow the efficient "joining" of queries that span several relations. For example, one relation might be manufacturer [manufacturer-name, address, city, state, zip], a second might be parts [part-number, part-name, weight, color, cost, manufacturer-name], and a third might be inventory [part-number, quantity]. A sample complex query might be "find all California manufacturers of blue down parkas that cost between $70 and $120, weigh under 4 pounds, and of which we have less than 10 in stock." For a very restricted subset of English words and syntax, natural language systems may be able to process the query directly and may even qualify the right noun with the corresponding relative clauses. In most systems, however, this must be translated by the user into a special query language with strong formal or mathematical structure. Ideally, the user does not have to worry about the structure of the actual relations, whether the relations are virtual or real, whether there are inversions, or on which machine(s) or long-term archives the information is stored, and can let the system locate the information optimally. Pragmatically, of course, the user may notice that certain queries are not possible when his personal computer is disconnected from the network or that queries of similar complexity are responded to in different amounts of time, which imply that there are differences at the system level.

Network models of knowledge were often used in earlier database systems (Carbonell, 1970) and are still used in artificial intelligence and computer science research (for example, the PIE system of Goldstein and Bobrow, 1981). An advantage of such representations is the inclusion of semantic information about the relations themselves to help in inferring additional knowledge automatically. Hierarchical models are a special case of networks in which nodes can be represented as trees or outlines, as, for example, in a biological taxonomy, in the interface of Thompson (1971) and frames in the ZOG system. Ullman (1980) compared these different models, with particular emphasis on the relational model. Kent (1978) described many of the pitfalls in any representation of information, especially those used in database systems. Although many assumptions about object names and data models may seem valid at the beginning of the design of a database, reality refuses to be so easily identified and described. New uses for old information, large amounts of the same kind of information, and new kinds of information to be included in an old database all tend to push a database design to its limits.

There has been major progress in freeing the question from the storage and representation of the data. However, the user interface or query language does change the way we might normally describe what we are looking for. A question originally conceived in our mind must be

symbolized in our native language and then mapped into some syntactic form resembling predicate calculus or into some graphic depiction of the organization of the information that might not match the way we would have organized it. In the earlier genealogical example, had we added a parent relation [name, parent], one could have asked about great-great grandfathers by asking for the information from relational tables, or had we organized it instead as a family tree (hierarchically structured), it might be easier to visualize and remember the family relationships. The fact that we use particular words to describe a concept may require us to change the wording of our request to utilize better a fixed-term subject index or to use the free text of the document itself. Some query language may eventually be superior to our native language in its power to describe complex relationships in the world around us that we call "information." One might argue then that that language should become part of our native language and part of our normal way of thinking about information rather than be something into which we (or some program) must always be translating our questions.

Browsing and Findit

The Findit system (Weyer and Kay, 1976) will be used to provide some further examples of databases and browsers as user interfaces, including a history textbook and a particular browser to be used in an experiment. The general term "browser" means a structure for describing some information and for viewing the results of that description. It provides a framework for query and manipulation languages. The user can simply select descriptions visible in a list or can compose a query that combines terms. The general connotation of "browser" includes both the kinds of unanticipated and serendipitous discoveries one might make while leafing through a magazine or wandering through the library stacks, as well as the more intense and narrow search process that progresses when one is looking for something quite specific.

The word "browser" is used below specifically to describe an area on a computer screen with many interrelated smaller areas: a "window" with many subparts or "panes." Tesler (1981) described the browsers that are used to view and modify the Smalltalk system. The Findit browsers described below borrowed the initial structure of these browsers. In a different line of evolution, Goldstein and Bobrow (1981) extended Tesler's Smalltalk-code browser to include more description of a programmer's development environment. (Other examples of windows may be found in Kay and Goldberg (1977) and Goldberg and Robson (1979).)

As the user rolls the mouse (a pointing device copied from the NLS system) across a table, a cursor (a small arrow) moves in the same pattern on the screen. The user makes selections by pressing a button on the mouse when the cursor is positioned at a particular item in a pane. Figure 3-1 displays a browser for an administrative manual. The hierarchical view shows two levels of naming and a document, in three panes: names of chapters in the top left pane, names of sections in the top right, and text of a document in the bottom. When a specific chapter is selected in the chapter pane, the chapter name is "complemented" (emphasized by reversing the video display -- instead of the usual black on white, white on black) and a list of that chapter's

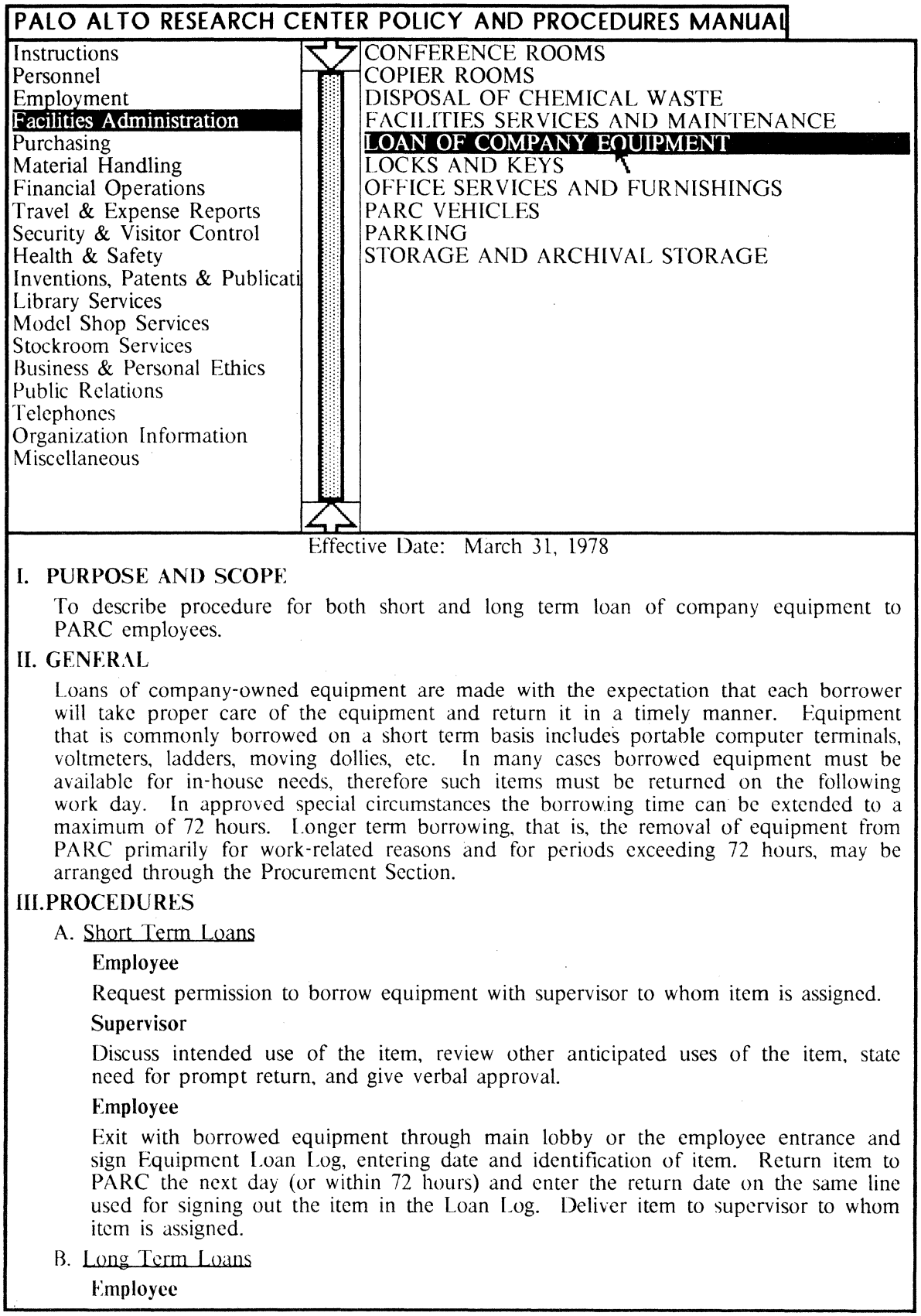

Figure 3-1. Sample: A Browser for an Administrative Manual

sections are displayed in the section pane. The chapter entitled "Facilities Administration" is selected in the figure. When a section is selected, the text for that section is displayed in the document pane. The cursor arrow lies to the right of the selected section "LOAN OF COMPANY EQUIPMENT." Other sections in the same chapter can be selected without re-selecting the chapter.

The *scrollbar* on the left of the section pane indicates that all of the sections are visible. In a long chapter, however, there may be more section names than will fit in the section pane. In this case, the gray rectangle would not extend all of the way to the bottom of the scrollbar. The top of the gray rectangle corresponds proportionally to the location of the first visible item in the pane in the possible list of sections. And, similarly, the bottom of the rectangle corresponds proportionally to the location of the last visible item. In other words, the location and size of the gray rectangle indicate approximately where the visible items are located in the list and how much is visible. By selecting the upward arrow at the bottom of the scrollbar, the user can "move the list up" by one item or line: the top item disappears and a new item appears at the bottom. Similarly, by selecting the downward arrow at the top of the scrollbar, the list can be "moved down." In some browsers, the gray rectangle can be "dragged" with the cursor to a new location, thereby jumping the list to make it match this spatial description.

Clearly, further structure (the headings with Roman numerals, and perhaps even the subheadings to those) could have been factored out of the document to add more levels to the naming hierarchy. A flexible browser should allow the user to specify at which level to flatten the rest of the hierarchy into a document, or, more generally, allow multiple selections to occur at several levels. The view in this browser is a sequential, hierarchical one -- one cannot locate material without first specifying a chapter and then a section. An alternative to this might be a browser based on keyword or free-text retrieval. Another browser for this manual could present the appropriate information from the point of view of an employee, supervisor, or accountant.

Figure 3-2 represents a simpler record structure in which the upper half of the window allows one to select a person's name (primary key), and the lower half of the window displays the corresponding telephone directory entry with attributes labeled on the left hand side. The upper half of the window might be considered hierarchical at first glance, and it is, but not in the same way as in the previous example. Here there is a single level of naming, a person's name, and the multiple panes each access the same level; in the previous example, each pane represented a different level of naming. Thus, a very long list of alphabetical names is displayed as a tree structure in several panes. The white pages of a telephone directory can be thought of as a two-level tree structure, with a discriminating name occurring at the top corners of each page, and further details, such as the names that lie in between the two corner names, occurring on the rest of the page.

Selecting a line in a browser pane that looks like "<<<<<" causes information that lies in between adjacent entries (or before the first entry or after the last entry) to be displayed on the right.

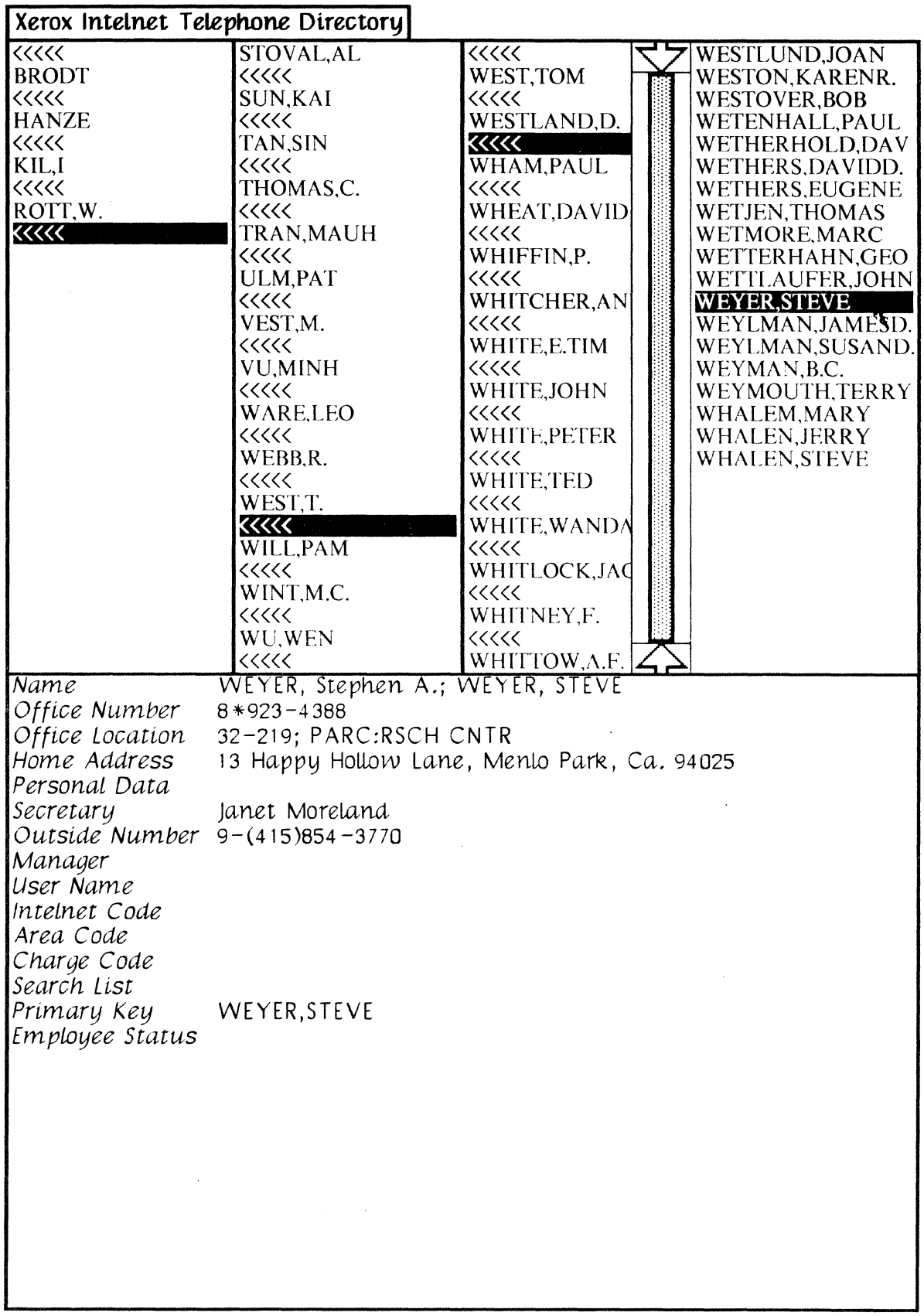

Figure 3-2. Sample: A Browser for an Office Telephone Directory

Depending on the length of the list, which is represented as a B-tree (Comer, 1979), there can be many levels of selection before you find the name you want, either at an intermediate level or in the final pane on the right. This is not a particularly good technique for selecting names because it ties the view of the name index with its actual representation. Selection of a name in this browser requires many decisions about alphabetical order, and much precious space on the screen is devoted to the display of information that might not be useful. Typing a name as a method for positioning the name index, a much more efficient method, will be discussed briefly later.

Figure 3-3 displays a secondary key index (Keys) in the top quarter of the window, followed underneath by a list of Titles, and finally by a single CACM record in the bottom half. A CACM record is a description of an article appearing in the *Communications of the Association for Computing Machinery*, a journal for computer professionals. The selection of key word phrases is identical to the selection of names in the previous example. However, selecting a secondary key does not necessarily result in a unique record as in the primary key case: the mapping is *one-to-many*. One solution would be to display all of the records in their entirety, one after the other. The technique applied here is similar: display all of the records, but summarize or filter them in some way, in this case by displaying the *Title* of each record. In most cases, titles are descriptive enough to serve as the basis for further selection. The unique "accession number" in the *End* attribute might have been used instead, but it offers little indication about the content of the document. Significant words in the selected keyword phrase are "highlighted" in boldface in the record (**data** and **abstraction**) (this is even more noticeable on the screen than the paper examples and figures indicate). Other systems (e.g., LEXIS) may also offer highlighting.

In Figure 3-4, the retrieval description in the upper pane is a form or template. The Findit system retrieves documents that match a sample document. This prototypical document is specified by filling in details within a template. In this case, the template specifies any CACM record containing a phrase beginning with "relational" in the Keys field, phrases such as *relational model* or *relational databases*. This is symbolized by *relational**, where * is a "wild card" that matches anything. In addition, it asks for articles whose author's last name is either "Chamberlin" or "Smith." For those familiar with query languages that use Boolean operators, this eliminates the need for special syntax when one is "or-ing within fields" and "and-ing between fields," because the syntax is implicit. The example might translate into a Boolean expression like (Author="Chamberlin,*" or Author="Smith,*") and (Keys="relational*"). Alternatively, in systems such as DIALOG, the user might specify each of the subexpressions as steps 1, 2, and 3, and then in step 4 specify the expression "(1 or 2) and 3." Because the parser for each field can be specified separately and easily in Smalltalk, more complicated expressions could be written. Other forms could be linked together to provide a two-dimensional syntax. A version of the Findit system with template retrieval has been in use in the Xerox PARC library for over five years to keep track of their book circulation and to print overdue notices. Zloof and de Jong (1977) described similar efforts to cast queries in a two-dimensional form, and add further credence to the idea of using examples or prototypes to describe the collection of

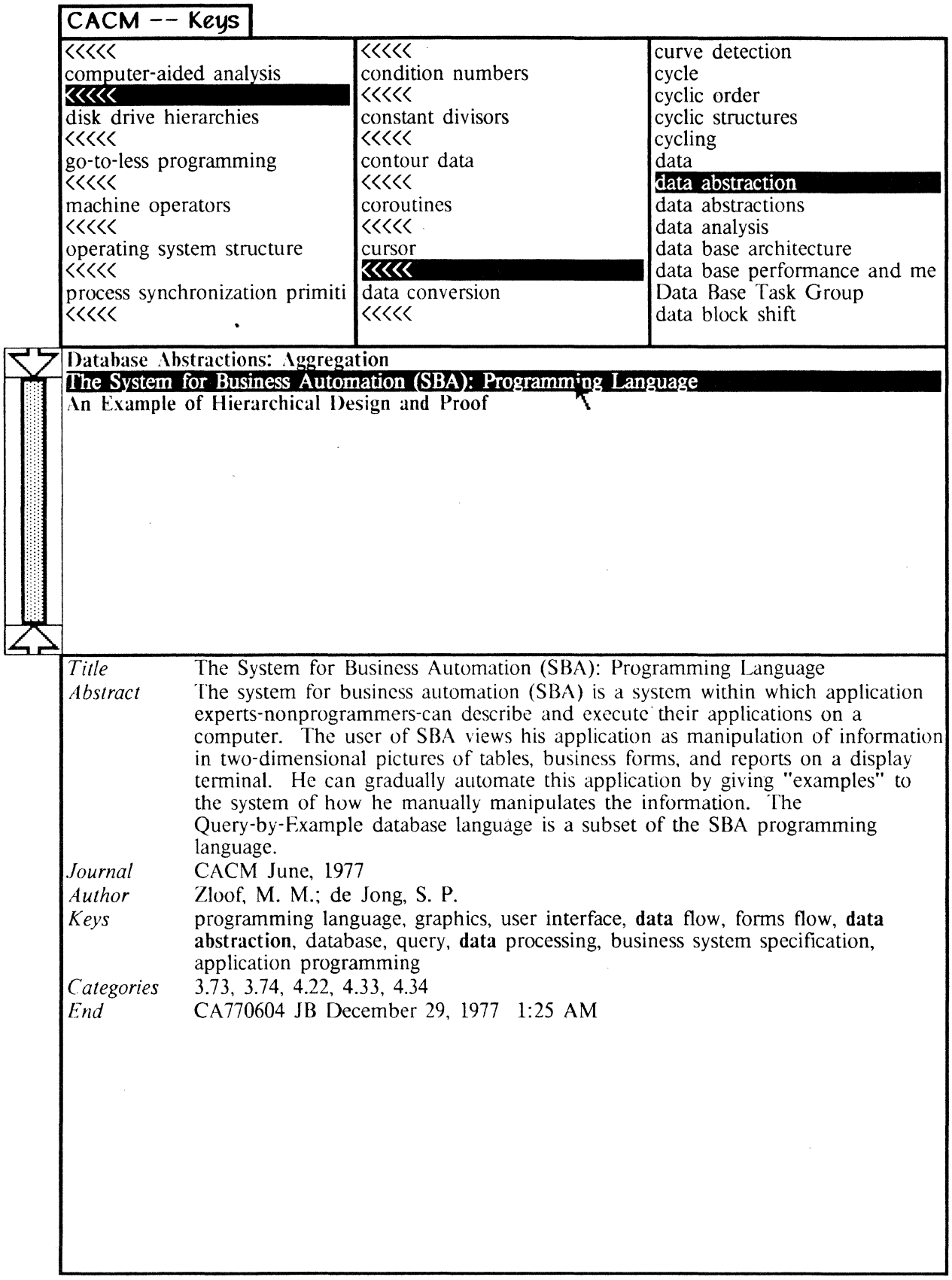

Figure 3-3. Sample: A Keyword Browser for CACM Articles

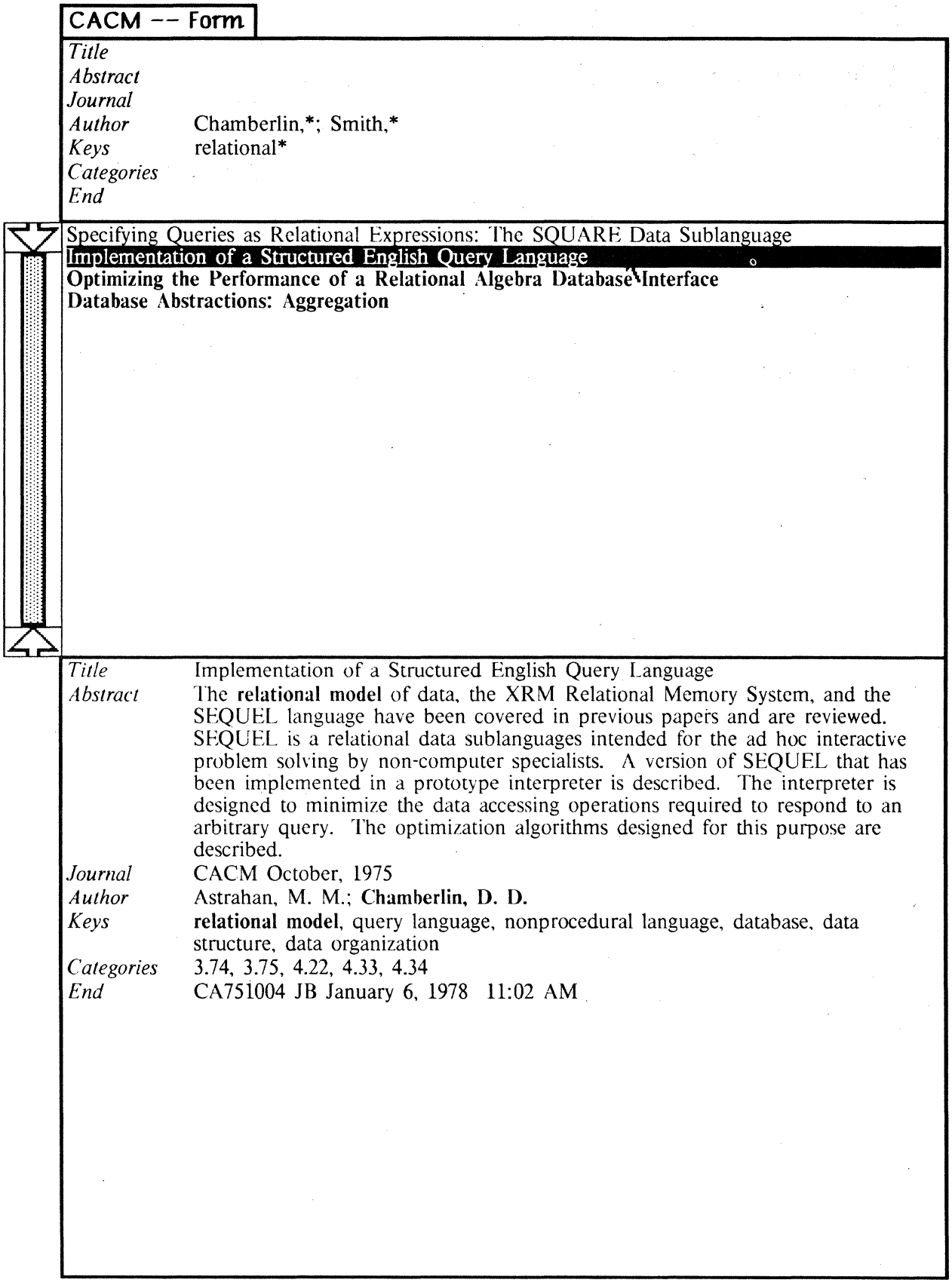

Figure 3-4. Sample: A Form Browser for CACM Articles

information one would like to retrieve. The abstract of their article appears in the example in Figure 3-3.

In Figure 3-4, specific words are automatically highlighted everywhere in the retrieved record, i.e., **relational model** and **Chamberlin, D. D.** In addition to the retrieval specification (of what to find), there should also be a view specification (of how to present the retrieved information) that can be edited easily. Among other things, this specification could limit the scope of highlighted words to specific fields (or eliminate them altogether), specify how the list of resulting records is to be configured (by title or sorted alphabetically by author, for instance), and specify how each selected record is to be presented (all or only some fields, or with text, graphics, or sound).

Figure 3-4 exhibits an additional feature in the central title pane. Unselected titles are displayed in boldface; once selected, they revert to normal typeface. For example, in the figure, the third and fourth titles are displayed in boldface. For long lists of items that are not accessed in first to last order, it could become quite easy to forget which items one had or **had not yet** examined. Instead of overloading short term memory, one could visually check things off from the list as they were selected. A related capability not shown in the figure is the marking of titles, where they are emphasized by underlining. This provides a way to retain important items that would normally be discarded when other items are retrieved from a new description. The NLS system implemented a similar function known as "freeze."

A Particular Dynamic Book

Three versions of a textbook were used in the experiment: Book A, called the "paper book," is the combination of an off-line paper printout of the textbook, and a simple user interface for selecting questions and entering answers; Book B is an "electronic book," which is structured and accessed as pages (like Book A); and Book C is a "dynamic book" (to be described in this section). Figure 3-5 depicts an initial view of the browser for Book C. For illustration purposes, the titles of all panes of the browser are displayed above their respective areas (though, in actual practice, only the pane currently containing the cursor displays a title, to avoid obscuring the bottoms of extra neighboring panes). The top three panes, *Commands*, *Question*, and *Answer*, are common to the browsers for all three books, and are used for presenting questions and collecting answers. Students using Book A have only these three panes visible. The remainder of the browser for Books B and C consist of on-line books, with dynamic functions such as highlighting, rapid access to subject terms, and help in managing lists of subjects and references. Book B is page-oriented, while Book C provides access to the text via 3 levels of headings (chapters, sections, and sub-sections) in the form of an outline (an expanded table of contents), and adds features for matching patterns in the subject index and accessing an inverted subject index. A description of the terminology and functions of Book C follows (a detailed comparison between the three books will be postponed until Chapter 4; the reader can refer to Appendixes A, B, and C for a description of the user interface for each book).

Commands	Question
start first question end this answer 0:00 (this question) 0:00 (all questions)	1. List four things that the concept of culture includes.

Answer

List of Subjects	Subject Index	Sub-Subject Index
	Aahotep Abbassids Abd-al-Rahman, caliph of S Abelard, Pierre Abraham Abstract expressionism Abu Saheli Abu-Bakr Abyssinia Acropolis	

List of Titles

Chapters	Sections	Sub-Sections
Prologue - Prehistoric Peoples: Pione OVERVIEW Interacting Civilizations in the Middle Egyptian Civilization in the Nile Valle		

Text

Subject References (Chapter)	Subject References (Section)	Subject References (Sub-Section)

Figure 3-5. Book C: An Initial View of a Browser for a History Textbook

Book C can be represented by the following relation: [Chapter Number, Section Number, Sub-Section Number, Heading, Text, Subject References]. The *Chapter, Section* and *Sub-Section Numbers* combined together are the primary key, although the user refers to the corresponding levels of the book by a *Heading* displayed in an expanded table of contents. References to the *Text* from the Subject Index are through "titles," concatenated from headings. For example, *Prologue - Prehistoric People...>Prehistoric Pioneers>Work of Archaelogists* contains the three headings (separated by ">") for the first chapter, first section, and first sub-section (referred to internally as (1,1,1)). *Text* is a variable-length field that can contain many paragraphs, all paragraphs occurring between the current *Heading* and the next heading in the book. The *Subject References* field, a secondary key, can be used to construct an inverted subject index that refers to chapters, sections, and sub-sections classified under that subject heading. For example, a sub-section of the book may be referred to by the subject terms *Archaeology, Fossils,* and *Choukoutien, China.* (In actual practice, these Subject Reference fields had to be constructed from the subject index supplied at the end of the book, but that is an artifact of the final published representation rather than the manner in which the indexing was done.) *Text* could be considered a secondary key if free-text search were used. If additional secondary keys such as *Geographical Area* and *Time Period* were added to the relation, other indexes such as a map and timeline could be used to access the book. Access to Book C, then, is either through the Title Index (hierarchy of Headings) or Subject Index (inversion of Subject References).

Figure 3-6 shows (in four miniatures) the overall design of the Book C browser. The browser can be divided for purposes of explanation into four major areas, each containing one or more panes. In the *Command Area*, the user selects and reads questions, keeps track of time, and enters answers. In the upper part of the *Subject Area*, the user enters subject terms and selects subjects from the subject index; the lower part of the *Subject Area* displays the subject terms related to the current part of the book displayed in the *Text Area*. The user selects titles in the *Title Area* from a list of titles or from a three-level hierarchy of chapters, sections, and sub-sections. The *Text Area* displays a portion of the textbook corresponding to the selection in the *Title Area*.

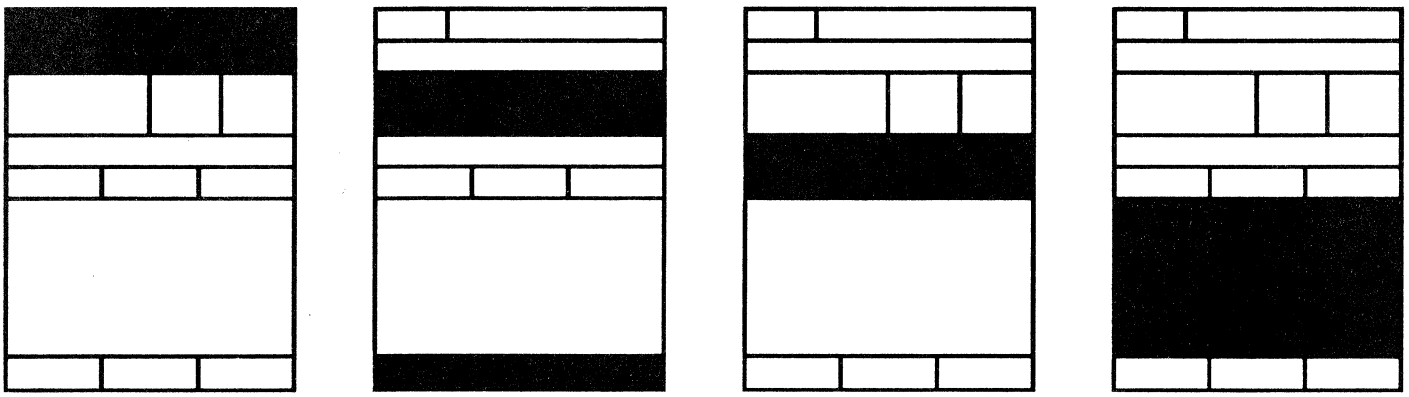

Figure 3-6. Book C: Layout of the Browser

Thus, the upper half of the window is used for experimental purposes, for accessing the subject index, and for managing lists of subjects and titles. The lower half of the window displays an instance of the Book C relation: the *Heading* is displayed in the lower part of the *Title Area* (this gives *Chapters, Sections, Sub-Sections*); the *Text* in the *Text Area*; and the *Subject References* in the lower part of the *Subject Area* in the form: *Subject References (Chapter), Subject References (Section), Subject References (Sub-Section).*

Several user actions mentioned earlier for other browsers are common to all parts of this browser. The user can read or scan what is already visible (this requires no command), including all text in the *Question, Answer,* or *Text* panes, or any list of commands, subject terms, or titles in the other panes. A scrollbar appears on the left hand side of each pane to indicate how much of the pane's information is visible. The user can change what is visible by scrolling information up or down, done by pointing at arrows on the scrollbar with the mouse. After moving the cursor into a pane, the user can select visible items with the mouse. Selecting items causes them to become temporarily complemented, and related information is displayed in nearby panes, replacing what was there earlier.

When the user selects a subject term, often the system displays a further list of subcategories or "sub-subjects." The user can narrow the search by selecting one of these terms, for example, *and the Commonwealth* under the subject heading *England* (written here as the compound subject:sub-subject: *England:and the Commonwealth*). Related terms are often found in the *Subject References* panes. After the user has selected a title, he can select a neighboring part of the book (chapter, section, or sub-section), based on the visible headings in the table of contents hierarchy (for example, see Figure E-3). Note that "hierarchy" is used here to indicate nesting of parts, and that the different levels may have different meanings. For example, in the history book, a chapter corresponds to a culture (continent or country) within some time period; a section, the next level, deals with more details of that specific culture, sequentially in time or by a topic such as geography, government, and religion; and the sub-sections, a third level, give yet more details within each section.

Subject terms that are selected can be added (copied) to the *List of Subjects* for later reference; similarly, titles in the title hierarchy can be added to the *List of Titles.* Items in the *Lists of Subjects* or *List of Titles* can be marked (frozen) so that they will not automatically disappear when selections in other panes are made. The appearance of items reflects their status: items in the subject or title lists that have already been selected appear in a normal typeface; new items that have not been selected appear in boldface; and items that have been marked are underlined. Thus, selection of items could be further differentiated on the basis of emphasis, i.e., selecting an old item, new item, or marked item. Items can be entered by typing in the *List of Subjects.* This can be thought of as a method of scrolling the *Subject Index* or of probing it for possible terms. In particular in Book C, the *Subject Index* can be probed for patterns, for example, **king of England**, with the resulting list of matching terms returned to the *List of Subjects.*

In Figure 3-5, we saw the result of selecting the command *start first question* in the *Commands* pane: the command is complemented, "1. List four things that the concept of culture includes" is displayed in the question area, and the other panes are initialized. The times in minutes that have elapsed for the current question and for all questions so far are continuously updated as the third and fourth items in *Commands*.

The particular layout chosen reflects a top-to-bottom and left-to-right flow for an assumed search strategy: ask a question, select useful subject terms, examine references and associated text, possibly return to the subject index with further terms generated from the text, subject references or the user, and eventually enter an answer adjacent to the question. Figure 3-7 shows the screen after a successful search and answer have been completed. The user typed *culture* in the *List of Subjects* pane, and the system centered the *Subject Index* alphabetically about this term. The user then selected *Culture, defined* in the *Subject Index*. (If the user typed or selected a term in the *List of Subjects* which matched a *Subject Index* entry exactly, such as, for example, *England*, the system would have automatically selected the term in the *Subject Index*; and, in the opposite direction, but for the different reason of de-emphasizing unreferenced subjects, if the user selected a subject in the *Subject Index*, and the same term existed in the *List of Subjects*, the system would also select the latter automatically.)

An additional level for this subject term was not displayed in the *Sub-Subject Index* on its right, as would have been the case for terms such as *Religion* or *England*, since it had none. However, a title did appear in the *List of Titles*: *Prologue -- Prehistoric People...>Prehistoric Pioneers>Work of Archaelogists*. This title contains three parts, separated by ">"s, that indicate the chapter, section, and sub-section headings referring to a particular sub-section of the book. After this title was selected, the corresponding selections were automatically made in the *Chapter*, *Sections*, and *Sub-Sections* panes, and text was displayed in the *Text* area. Exact occurrences of words from the current subject term, such as **culture**, are emphasized in the *Text* area in boldface. Related subject terms that refer to the same chapter, section, or sub-section are listed in the *Subject References* panes at the bottom of the browser. After reading the text, the user types an answer in the *Answer* area, and selects *end this answer* in the *Commands* area.

Interaction of Tactics with Books

Of course, not all questions can be answered this easily. Questions can require complex search tactics or examination and manipulation of many items of information. Features included in the design of browsers can augment these search and management processes. Ideally, the set of operations permissible in a browser should match and amplify the tactics used by the searcher (one such toolbox of search tactics was presented earlier in Tables 2-1 and 2-2). A question that compares the results of irrigation in several cultures, for example, or contrasts the educational opportunities for women in different time periods can be answered using a traditional paper textbook. However, to do so, the user may have to take notes, flip back and forth between the subject index and main text many times, remember many preliminary details, or leave bookmarks

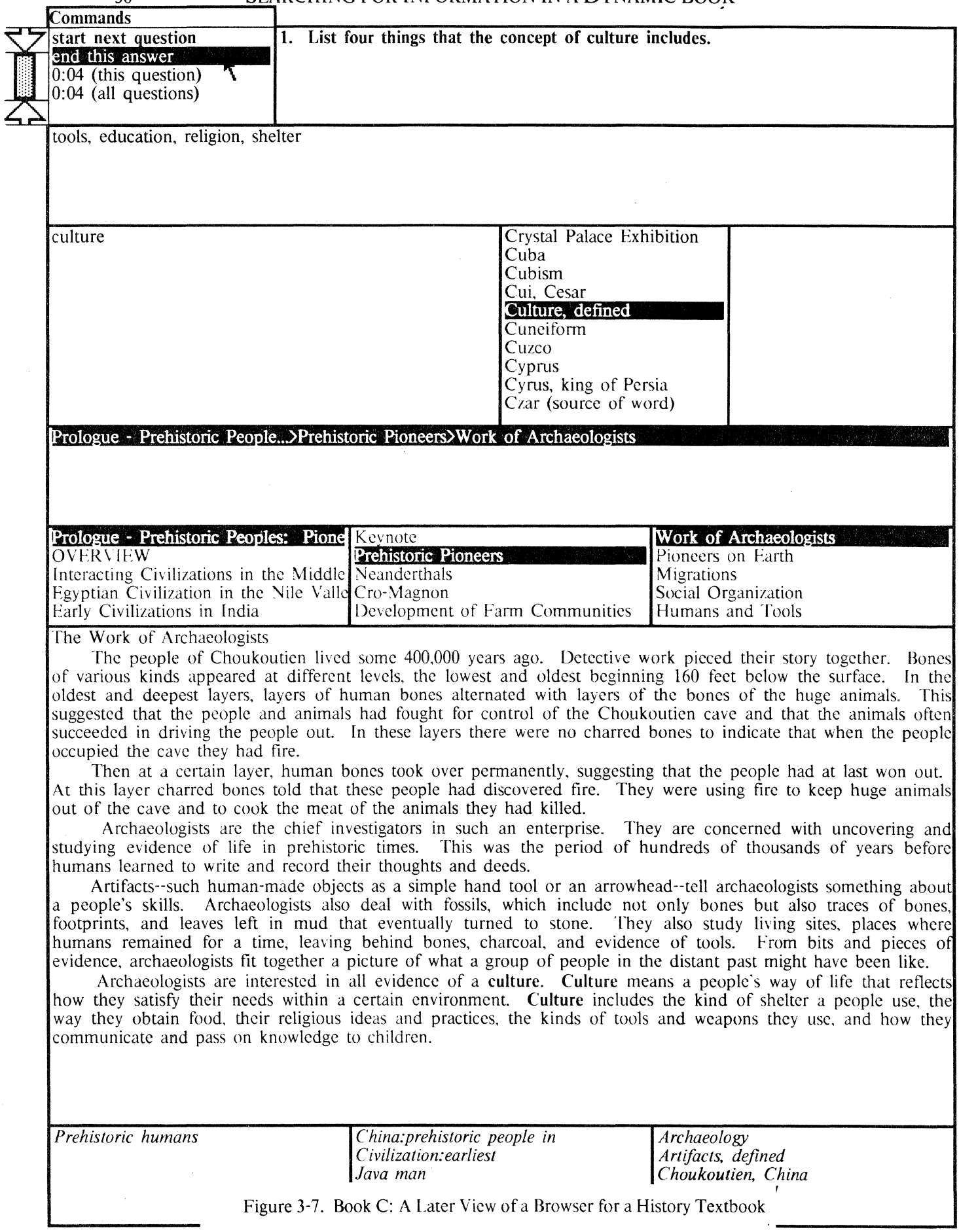

Figure 3-7. Book C: A Later View of a Browser for a History Textbook

at several places in the book, a cumbersome application of "M5.Record -- To keep track of trails one has followed and of desirable trails not followed up or not completed." In Book C, the user can see the subject index, neighboring subject terms, a selected subject and its associated list of references, and a portion of the text on the screen at the same time. This would be analogous in the paper world to having two textbooks, one book opened to the subject index with the current subject heading circled, the other book opened to one of the corresponding page references. Emphasis in the *List of Titles* could help keep track of which references had been examined, just as checking off the page numbers under the corresponding subject could help the user of a paper book. The Book C user could add subject terms to the *List of Subjects* on the screen for later referral instead of having to probe for the term again; the analogous paper-book action would be to keep a list of subject headings to examine again, and to leave tabs on the appropriate pages of the subject index. After locating a particularly relevant part of the book, the dynamic-book user could mark the title, just as the paper-book counterpart could leave a labeled bookmark in the text. A superior method of comparing similar items might be to display several text entries in their entirety, adjacent to one another. Designs of user interfaces are tempered, however, by constraints about how to lay out the information on the available, never-large-enough screen, and about how the user may most easily learn about and control the interface. For example, using a smaller typeface might increase the amount of information displayed but make it less readable.

A question with multiple parts may be more easily handled if the student could type in a partial answer, interrupt this by further search, and continue to add new information or erase previous information. The Book C browser (as do the browsers for Books A and B, as well) permits the user to type while the cursor is in the *Answer* area and to freely change to another activity by moving the cursor to another area. It might be natural to answer a sequence of separate questions in an analogous fashion, by perhaps skipping a question or answering it partially, going to the next or some later question, and returning later to the original question. However, to simplify the user interface and to eliminate the possible influence of later questions on the search strategy for earlier questions, a linear order for questions was adopted in the *Command* pane.

Questions containing many potential subject terms may require probing the subject index many times. It is important not only to find out quickly whether a term is present and to which titles it refers, but also to locate alphabetically neighboring terms if the original term is not there. Books provide a large neighborhood of terms in an entire column or page, but flipping pages and scanning for names may be relatively slow. A computer system, though it may be much faster, might provide no neighborhood or only a small one of just the nearby terms. In Book C, only ten subject terms and ten associated sub-subject terms are visible at a time, although the list can be scrolled. In addition, text at the end of long subject terms may be hidden from view.

Searching for dated events can be nearly impossible in an alphabetical subject index if the date is mentioned only later in the term, e.g., *Concordat of 1801*. Similarly, the subject index might contain no entries under *king*, although there are entries of the form *Charles I, king of England.* Allowing the specification of subject patterns such as **1801** and **king of England** would allow

access where none was feasible before -- the systems enters matching entries in the *List of Subjects*. An alternate solution with similar results would be to include additional alphabetical index entries in a KWIC format, e.g., *1801, Concordat of* and *king of England, Charles I.* Another design might provide search for patterns in the text itself (free-text search), and make it possible to locate information not easily described in the subject index. However, the subject index might be more effective at succinctly specifying complex concepts, e.g., *England:representative government in* than would the free-text approach. The design selected for the Book C browser, i.e., pattern searches in the *Subject Index*, leaves the original subject index intact, but uses a hybrid KWIC/free-text approach to change the style of access.

After unsuccessfully probing the subject index or locating a part of the book that is not quite what was wanted, the user is faced with the task of starting the search over or refining a potentially successful line of attack -- the application of Search, Term, or Idea tactics. The subject index may suggest a subject cross reference, for example, "Farming, see Agriculture," or "England, see Great Britain." The text itself may contain clues to related people or events, such as who was a given king's father or what events triggered a given war. The *Subject References* panes of Book C are intended to provide additional cross references for a given chapter, section, or sub-section of the book, and show what other terms are available in the subject index to describe the current text. Thus, subject references could be a source of synonymous and related terms. For example, a section about women in Japan that discusses voting rights would indicate in *Subject References* that a related term is *Suffrage:Japanese*. The discussion of a particular war might make references to the subjects of *Weapons* and *Military*, which might then be used to alter the direction of the search.

When one normally looks up a subject in a subject index, one is referred to a page number or collection of page numbers in the book. Referring to a part of the book by its title, composed of chapter, section, and sub-section headings, could provide a preliminary clue as to whether the text is worth examining or not. (In a related way, access to neighboring parts of the book through the heading hierarchy would be a use of a File Structure tactic.) For example, in a question about medieval Japanese armies, i.e., samurai in the feudal era, one might look under *Military:Japanese*. In a page-number-oriented index, the references would be "538-539." In a title-oriented system, this reference would appear as *Tensions and Problems Lead to World War II>Militarism in Japan, and Revolution in China>Business-Military Conflicts*. With the prior knowledge that World War II did not occur in medieval times, the user could avoid selecting the section at all. Of course, in a system where no noticeable delay occurs between selection of a page and its display on the screen, examining extraneous information might not be a problem. In the current system, however, the retrieval and highlighting of a single *Text* entity (sub-section or page) can sometimes take up to two seconds. Partial solutions, then, are faster computer hardware and more efficient software implementations. However, if many parts of the book are to be examined, then it is desirable that headings accurately summarize content, so that the user can select the most relevant titles first.

A reader of the *Text* area might be helped or distracted by the highlighting of significant words. For example, in a lengthy, dense section which lists the names and achievements of many modern musicians and composers, the reader could skip over the intervening material to **George Gershwin**, which appears near the end. However, the reader might miss valuable structure from the order of presentation, as well as interesting details that might have been learned incidentally. Rather than highlighting only exact significant words from the subject phrase as in the browser presented here, the user might want to have nothing highlighted, or only proper names emphasized, or words in the question itself or any collection of words ignoring suffixes.

This section has presented the design of some information browsers, especially one for a dynamic history textbook (Book C). Chapter 4 will compare Book C with Book A (the paper book) and with Book B (the electronic book), and then describe an experiment that uses them.

Chapter 4. An Experiment in Information Seeking

This chapter describes an experiment that examined the uses, for answering questions, of several related books. Students came on two consecutive days: on one day, each student answered questions by using a paper version of a world history textbook -- this was the control treatment; on a different day, each student answered a similar list of questions using an electronic or dynamic version of the same textbook. Chapter 5 will analyze student search tactics, and also compare groups on the basis of preference and performance on this experimental task.

The Books

Creating a dynamic book from scratch was considered an unrealistic option for conducting this experiment, both in generating the content and in implementing unknown dynamic features. A source of information such as a recent *Encyclopaedia Britannica* would have been a rich and interesting database; the articles in it are organized in alphabetical order (its primary dimension), and they are interconnected through the structures of the *Micropaedia* and *Propaedia.* These books are slowly becoming available in digital form, but not necessarily in a way that would allow detailed measurement of use and experimentation with user interfaces. The same criticisms also apply to systems such as DIALOG and NEXIS. As communications between computer systems are carried out at a higher level of description, it should be possible to use a single interface, whether driven by menu selection, by filling in n-dimensional forms, or by phrasing questions in a query or pattern language, to evoke information from all of these currently incompatible systems. This is another valuable area, but one that will be left for future research.

Although publishers have begun to use word-processing systems for editing manuscripts, and one would imagine that many textbooks are available in digital form, such is not the case. But one of the textbooks in the history or world culture domain, that had been considered a plausible text for these purposes, did become available in digital form. This high-school-level world history textbook is *Our Common Heritage: A World History* (Roselle, 1981), used by permission of Ginn & Co. If a set of coordinated books such as a geography, biographies, and works of literature were available in addition to world history, an experiment in inter-book search would have been possible. One book, however, was considered a large enough domain for the present experiment.

Our Common Heritage was written for the paper media and its primary dimension is time: for a given historical period, geographical areas are treated successively -- by era, then area. The subject index is alphabetical and contains terms referring to countries, people, events, and cultural concepts, all intermixed. Subject entries may be missing and symmetric entries (*France:religion in* and *Religion:in France*) may not refer to the same parts of the book. All in all, it is a typical textbook, and can be made dynamic. During some future period of transition while new dynamic books are being created and old books are gradually recast in dynamic form, many books might be converted into intermediate forms, similar to the "electronic" and "dynamic" versions of *Our Common Heritage* used in the experiment.

The published version of this book was not actually used in the experiment. Instead, a paper version was printed from the digital sources (and these differed from the published version as described later). This, used in conjunction with a simple user interface for presenting questions and entering answers, was designated Book A. The electronic and dynamic book versions, Books B and C, were based on the same digital sources. For simplicity, Book A will be often used interchangeably with the term, "paper" book, Book B with "electronic" book, and Book C with "dynamic" book. However, these labels may be misleading because Book A is not the published textbook but a loosely bound printout used in combination with an on-line user interface, Book B has several features usually considered dynamic, and Book C is by no means the best possible dynamic book. The three books will now be described and differentiated from one another.

Book A -- "paper" book

Book A consists of simple user interface on a computer screen and a paper version of the textbook that was printed on 8-1/2" x 11" paper from the digital text sources, and presented in two binders. It differs from the actual published textbook in several ways. First, it does not include graphical information. Pictures and maps were excluded because they were not available in digital form, and because it would be technically difficult to get the correct color and resolution. Second, the two-volume binder book may be more cumbersome to use than the one-volume published book, although it gave the advantage that the subject index at the end of the second volume could be left open while reading pages in the first volume. Third, Book A was printed on only one side of the paper for convenience to the experimenter. (The text in Books A, B, and C is presented in a single page-wide column, while text in the published book is presented in two columns per page.) Finally, because the digital sources were from the book galleys but not final page proofs, the published book contains some later corrections to spelling, changes in wording, and page references within the text itself, such as "see page 273" in the published book vs. "see page 000" in Books A, B, and C. Although Books A, B, and C differ from the published version of the book in these ways, there were no content differences between the three Books.

Book A was located on a table adjacent to the Alto computer terminal. A window on the computer screen was used to present questions, keep track of time, and record answers, not only for Books B and C, but also for Book A. The computer was used in association with Book A to facilitate data collection and to reduce the novelty effect of using a computer to answer history questions. Students used the mouse to indicate different panes within the window and to execute commands, such as *start next question.* They typed in answers using the keyboard. The top of Figure 4-1 shows an image of the computer screen after a student has answered the sample question "List four things that the concept of culture includes." Figure 4-2 contains a segment of the subject index and a portion of page 3 from Book A. Appendix A was used as a guide for students and provides a more detailed description of the computer interface, including mouse, windows, panes, and user actions.

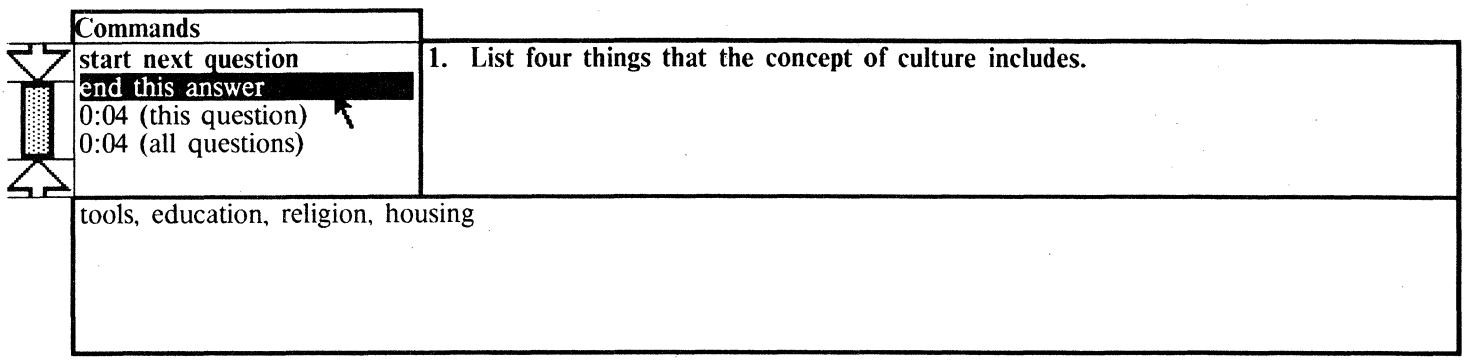

Figure 4-1. Book A: A Browser for Questions and Answers

Common Attributes of Books B and C

The windows for Books B and C have the exact same area for presenting questions and recording answers as does Book A. In addition, Books B and C use the remaining part of the computer screen to present an electronic or dynamic textbook. Figure 4-3 shows an initial view of the screen for Book B after the question about culture is selected; Figure 4-4 shows the result of answering the question using Book B. Figures 3-5 and 3-7, presented in Chapter 3, show the "before" and "after" views of the screen for Book C. Appendix B, appended to Appendix A except for its last two pages, was used as a student guide for Book B, and Appendix C provided a student guide for Book C.

What is the dynamic nature of Book C (and, to a lesser extent Book B)? Some of the following items were discussed for Book C in Chapter 3 but will be briefly repeated here. In each book, students access the subject index by typing partial or entire terms in a subject list area in order to position the subject index alphabetically. They then select terms that appear in the *Subject Index* and *Sub-Subject Index* by pointing with the mouse. For example, typing "hu" may be sufficient to make *Hundred Years' War* become visible on the screen with a short list of subject terms. Terms that are nearby alphabetically can also be viewed by scrolling the subject index forward or backward, for example, to find *Ice Age* or *Hottentots*. In both Figures 3-7 and 4-4, the user typed "culture" in the *List of Subjects* which centered the *Subject Index* around this term, and then selected *Culture, defined*. In contrast, the subject index in Book A must be manually searched to locate the page and the place on the page for a term; on the other hand, many more terms are shown on the paper page than on the dozen lines displayed for Books B and C.

In Books B and C, students could add terms to a list from the subject index for more exact later referral. In Book A, students could achieve the same effect by using bookmarks or their fingers to mark the exact place in the subject index. References to the text, whether by page number, as in Book B (*List of Pages* in Figures 4-3 and 4-4) or by title, as in Book C (*List of Titles* in Figures 3-5 and 3-7), could be discriminated as examined or unexamined, depending on the typeface emphasis. This discrimination is similar to that shown by checking off page numbers as they are accessed under a subject term in a paper book. These references can also be marked for later referral, similar to leaving a labeled bookmark in the text.

Cubism, 441, 625
Cui, Cesar, 477
Cuneiform, 25-26
Culture, defined, 3
Cuzco, 230, 231
Cyprus, 599
  British in, 480, 515
  Turkish-Greek war over, 607
Cyrus, king of Persia, 33

3

Choukoutien cave and that the animals often succeeded in driving the people out. In these layers there were no charred bones to indicate that when the people occupied the cave they had fire.

Then at a certain layer, human bones took over permanently, suggesting that the people had at last won out. At this layer charred bones told that these people had discovered fire. They were using fire to keep huge animals out of the cave and to cook the meat of the animals they had killed.

Archaeologists are the chief investigators in such an enterprise. They are concerned with uncovering and studying evidence of life in prehistoric times. This was the period of hundreds of thousands of years before humans learned to write and record their thoughts and deeds.

Artifacts--such human-made objects as a simple hand tool or an arrowhead--tell archaeologists something about a people's skills. Archaeologists also deal with fossils, which include not only bones but also traces of bones, footprints, and leaves left in mud that eventually turned to stone. They also study living sites, places where humans remained for a time, leaving behind bones, charcoal, and evidence of tools. From bits and pieces of evidence, archaeologists fit together a picture of what a group of people in the distant past might have been like.

Archaeologists are interested in all evidence of a culture. Culture means a people's way of life that reflects how they satisfy their needs within a certain environment. Culture includes the kind of shelter a people use, the way they obtain food, their religious ideas and practices, the kinds of tools and weapons they use, and how they communicate and pass on knowledge to children.

Pioneers on Earth.

Prehistoric human fossils and artifacts have been found in many parts of the world. The people they represent truly were pioneers. They had to learn to cope with environments that, with respect to climate, vegetation, and animal life, were sometimes unfriendly. They had to develop some means of verbal communication. They had to discover sources of food and how to fashion tools and clothing from materials on hand, at first learning as they went. And, for the group to survive, they had to pass on their knowledge to their children.

Fire was a primary tool, and no one knows how humans first acquired it. Fire offered a means to render meat more tender and tasty. It helped protect humans against wild beasts. Used to ignite a dried grassland, it could frighten animals toward a place where hunters lay in wait. Fire, of course, also conquered the darkness of caves and the night.

Migrations

It is likely that the earliest humans lived in such tropical regions as central Africa and Java, where the climate was warm the year round. They were hunters of animals and gatherers of fruits, nuts, seeds, and roots. It appears that humans gradually spread out from these areas over long periods of time into northern Africa and into Europe and Asia.

Figure 4-2. Book A: Excerpts from Subject Index and Page 3

Commands	Question
start first question end this answer 0:00 (this question) 0:00 (all questions)	1. List four things that the concept of culture includes.

Answer

List of Subjects	Subject Index	Sub-Subject Index
	Aahotep Abbassids Abd-al-Rahman, caliph of S Abelard, Pierre Abraham Abstract expressionism Abu Saheli Abu-Bakr Abyssinia Acropolis	

List of Pages	Page Index
	1 2 3 4

Text

Figure 4-3. Book B: An Initial View of the Browser

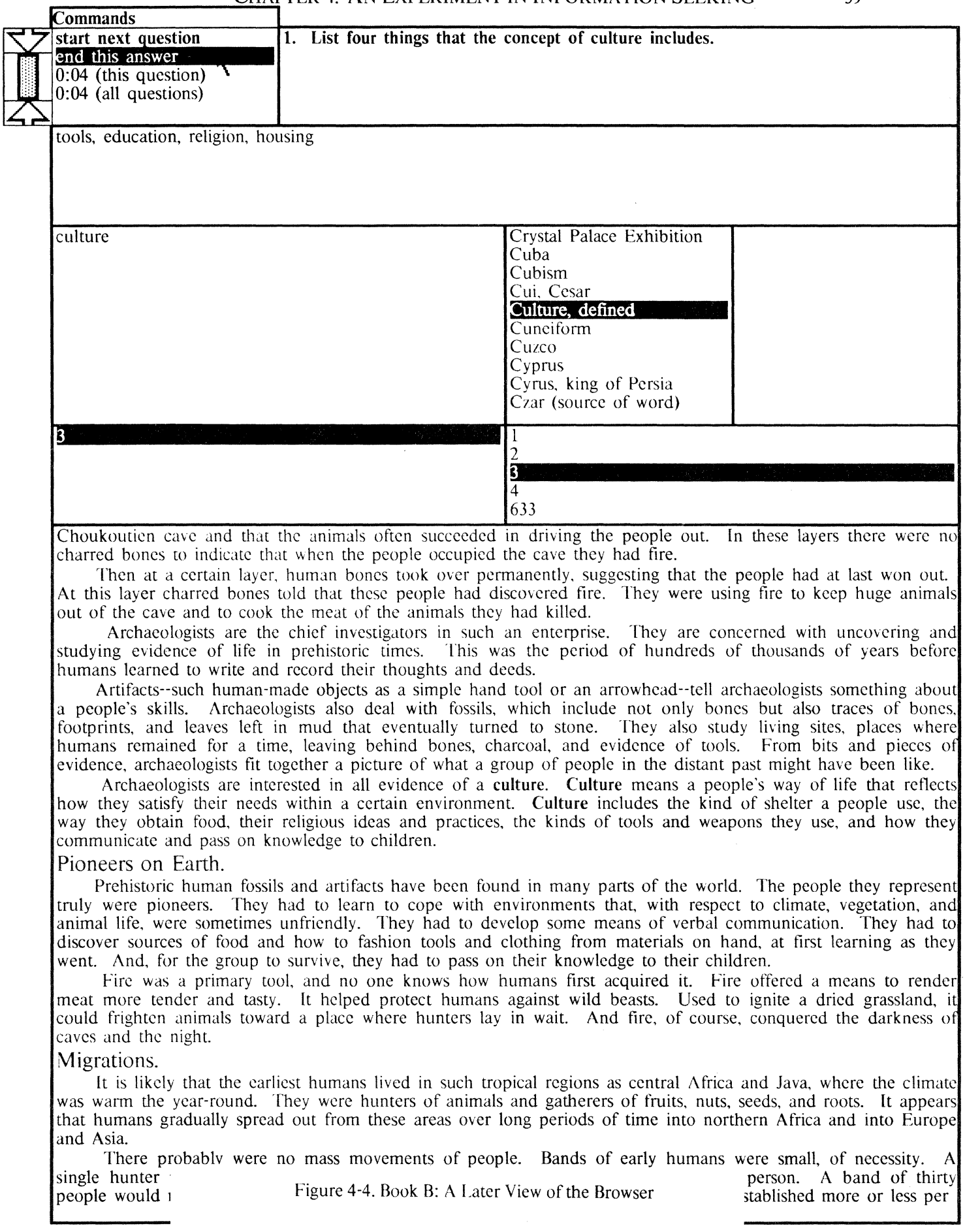

Figure 4-4. Book B: A Later View of the Browser

Another aspect that the two books B and C share is the ability to emphasize or highlight words in the displayed text. Each exact occurrence of a word from a subject phrase is emphasized in **boldface** everywhere it occurs in a selected section or page of the book. For example, words in the subject phrase *Culture, defined* are emphasized in the displayed sub-section (Figure 3-7) and page (Figure 4-4), as in **culture**. Insignificant words such as "the" and "of" are ignored. Suffixes are not treated specially, thus "wars" or "cultural" in the text will not be highlighted when "war" or "culture" is part of the current subject phrase. For example, after selecting the subject phrase *Akbar, king of India*, subsequent occurrences of Akbar, king, and India in the text would appear as **Akbar**, **king**, and **India**; of, kings, kingdom, and Indian would not be emphasized.

Book B -- "electronic" book

Book B lies between Books A and C in complexity. It, like Book A and the "softcopy" manual of Rouse and Rouse (1980), is page-oriented, and thus might be considered merely electronic. However, it does offer the dynamic features of rapid subject-access, adding, marking, and highlighting. It does not, though, in contrast to Book C, allow subject pattern searches or display subject references. Students can turn pages by either typing or selecting page numbers. Section and sub-section headings are displayed in a larger font size within regular-sized text in Book B rather than displayed separately as in Book C. A larger area is devoted to text display in Book B than in Book C, but pages tend to be longer than sub-sections or section introductions in Book C.

Book C -- "dynamic" book

Book C offers a hierarchical view of the headings and text rather than a page-oriented one. It displays the subject terms that refer to the currently displayed levels of the book in the *Subject Reference* areas, and allows searching for subject-term patterns in the *Subject Index*.

Access to the text in book C is through chapter, section, and sub-section headings rather than page numbers. In addition to the chapters listed in the table of contents, the section and sub-section headings are included in an expanded outline, resulting in a three-level, hierarchical organization. References to parts of the book are through names or titles of the form: chapter>section>sub-section, for example, "Chapter 15. The Rise of Trade, Towns, and Nations>Townspeople Develop New Ways of Living>Women and Courtly Love." The subject index refers to these titles instead of page numbers, so, for example, *Culture, defined* refers to the title *Prologue -- Prehistoric People...>Prehistoric Pioneers>Work of Archaelogists* in Figure 3-7. Selecting a title from the *List of Titles* positions the textbook to the appropriate chapter, section, or sub-section. In addition, a student can browse this hierarchy directly to read the succeeding or preceding sub-section, section, or chapter. Subject references appear for each corresponding level of this hierarchical structure in the *Subject References* panes at the bottom of Figure 3-7, so that there are lists of all of the subject headings that refer separately to the current chapter, section, and sub-section.

Students can also specify patterns in the subject index. For example, neither *king* nor *1801* are present alphabetically in the subject index. The result of typing the patterns **king** and **1801** would be to display all subject index terms that contain these words anywhere, not just at the beginning of the phrase. *Charles I, king of England* and *Concordat of 1801* would be some of the terms obtained from such searches.

In summary, Books A, B, and C possess the attributes listed in Table 4-1. These may have an impact at several points during the search process: in the generation of subject terms (subject-pattern matching and inverted subjects of Book C); in faster probing (fast, random subject index access) of the subject index for the existence of terms; in the tracking of immediate (title emphasis in Book C and page-number emphasis in Book B) and saved (subject-adding; title- and page-marking) items; in locating words within a sub-section or page of text (highlighting); and in locating information nearby in the book's primary structure (the heading hierarchy of Book C).

Table 4-1
Summary of the Attributes of the Three Books

Book is on paper	A		
Book is on-line:		B	C
"electronic"		B	
"dynamic"			C
User selects questions and enters answers on a computer screen	A	B	C
Book accessed by page numbers	A	B	
Book accessed by chapter, section, and sub-section headings			C
Book highlights subject words in text		B	C
Book emphasizes page numbers			
User can add/mark pages		B	
Book emphasizes titles			
User can add/mark titles			C
User has fast subject index access		B	C
User can add subject terms		B	C
User can match subject patterns			C
User can add subject references			C

Other features to enhance search were considered for other possible versions of dynamic books. In an early system, a version of free-text search was implemented but proved awkward to use; more importantly, its effective use would have required extensive user training in selecting discriminating words and in specifying patterns and combinations thereof. For example, the words "king" or "religion" or "England" alone would have returned too much information and would have had to be qualified by other words to constrain the results to a more manageable size.

Creating a more semantically structured subject index was another design possibility. In addition to listing all subject terms by alphabetical order, we could have grouped them in a conceptual hierarchy or network. For example, "Charles I, king of England" might have appeared under the term "kings" or "English kings," either of which could then have been under the broader classification of "political figures" or "important individuals." "Yellow River" might be found under the more general to specific descriptors, "Bodies of Water," "Rivers," and those, in turn, under "Geographical Features." No existing category system was found suitable to encompass the content of the book, and the exercise of constructing a possibly arbitrary categorization and then restructuring the subject index appeared too time-consuming to pursue. It would be a necessary step, however, in any future systems that attempt to represent the subject area and understand it sufficiently to draw inferences and offer help (e.g., Carbonell's (1970) South American geography tutor).

The list of 36 chapters listed in the Chapter pane of Book C could have been further segmented into 10 "Units" of from 2 to 5 chapters each, where each unit introduced a common time period or theme (such as, for example, "early civilizations" or "the industrial revolution"). The heading hierarchy then would have contained 4 levels: units, chapters, sections, sub-sections. In addition to complicating the already-full screen layout, this would have also made the heading hierarchy more difficult to comprehend and use for locating nearby information. Rather than adding this structure, we regarded units as short chapters that preceded groups of chapters (units were indicated by "chapter" names appearing in all capital letters, e.g., UNIT 1. CIVILIZATIONS DEVELOP IN FOUR REGIONS).

A last example of an unimplemented feature that would have influenced the process of search is that of allowing the students to copy words directly from the text of the question to the *List of Subjects* area rather than having to type the subject word. For slow typists and long and complicated subject terms, this might streamline the probing process. However, it might also bias term selection to be primarily those words present in the question, and typing would still be necessary if this approach failed.

Software and Hardware

The software system used in the experiment was part of the Findit system implemented in the Smalltalk programming language, described in Chapter 3. In addition to being the implementation language for Findit, Smalltalk was used in several other ways to support the work

in this dissertation: it provided data summarizing and replay of student sessions, statistical analysis and graphing, and the generation of figures for the student manual (Appendixes A-C).

The text files for the textbook, index and inversion files, and combined Smalltalk and Findit systems each occupied approximately one third of the 4-million total bytes of information. The book consisted of 633 pages, divided into 36 chapters, 230 sections, and 1220 sub-sections that consisted of several paragraphs each. There were 2373 subject headings, and of these, 2136 had no sub-subject categories or cross references; the remaining 237 subject headings referred to a total of 2195 sub-subject terms and 81 cross references.

Students used two different Xerox research computers: an Alto computer (Thacker, McCreight, Lampson, Sproull, Boggs, 1982) for Book A, and a faster computer, a Dorado (Lampson and Pier, 1980), for Books B and C. Other than by their relative speeds, these two machines could not be distinguished by students. The workstations for both machines consisted of a standard alphanumeric keyboard, a mouse for pointing, and a black-and-white bitmap display screen measuring approximately 8-1/2" by 11", with 72 dots per inch of resolution.

Design of the Experiment

Students answered questions from one list with Book A on one day, and answered questions from the other list on another day using either Book B or C. The experiment uses a fully balanced design that involves four different book presentation orders, and two different question list orders, for a total of eight different conditions. Table 4-2 shows that two students were assigned to each condition, for a total of sixteen students. Availability of students and computer resources constrained the study to this size.

Table 4-2
Number of Students per Condition

Question List Order	Book Order			
	AB	BA	AC	CA
12	2	2	2	2
21	2	2	2	2

As will be seen later, this design allows control vs. experimental performance comparisons, for both A vs. B, and A vs. C. Although these can be viewed as two separate experiments, because Book A is common, we can also make an indirect comparison between the two experimental Books: B and C. A more obvious design involving all three books and three question lists, e.g. ABC and 123, would have involved many more students over more time, and in any such within-subjects design, interactions between books, especially as might be expected between B and C, could seriously confuse the results. A fractional factorial design could reduce the number of students needed by examining only some of the book-list combinations, but would still suffer the same interactions between the three books.

Questions

The questions dealt with aspects of world history that could be answered by finding and reading a section or several sections of the textbook, without reference to pictures or diagrams. Questions were fairly specific about what to supply for an answer: for example, "Name three things that the Crusaders brought back with them that changed European culture" instead of "How did the Crusades affect Europe?". Answers were intended to be short sentences rather than longer essays, so that they could be graded easily, and so that students could spend more time looking for information and less time composing and typing. Questions varied in complexity, both in content and in the variety of search strategies necessary to find relevant information; not all questions were necessarily factual or worded to suggest the right search terms or categories to use.

Some questions were easy to answer because some significant word(s) in the question could be used directly as search terms, as was the case with *Etruscans* in question 1-1: "Where did the Etruscans come from and whom did they conquer?" This question asked for several pieces of information that could be found in the same part of the book. In form, it has *multiple* questions; in terms of search requirements, it required one *simple* access to the subject index and text. Several questions required terms not directly mentioned in the question in order to reference the information, e.g., the term *Suffrage* in question 1-8: "What was the first country to give women the same voting rights as men?" This was a *single* question, but required *indirect* subject access.

Another question required the student to examine one section of the book first in order to find a subject term that then referred to the desired information; take *Social welfare* in question 1-14: "What three legislative acts in Germany provided protection similar to that of Britain's National Insurance and Assistance program?" This could be considered an *analogy* problem of the form: Britain is to the National Insurance and Assistance program as Germany is to ?, and required *multiple* access to the subject index and text. This might also be interpreted as *indirect* access. Several questions, such as question 1-15, asked for several pieces of information from possibly different parts of the book: "What probably started the War of the Spanish Succession? What was this war called in North America and which two countries fought there? Which treaty ended the war?" This was a *multiple* question in form, requiring a *simple* subject access but possibly *multiple* references to the text itself. Question 2-9: "Name an Italian Renaissance composer and two Baroque period composers" is a *multiple question* that employs *multiple attributes* in the description. This may require the searcher to adopt a nested approach to accessing the subject index in addition to multiple accesses to the subject index and text. *Comparison* questions imply *multiple access* to the subject index and text and require the student to integrate what was found, as in question 1-17: "Briefly summarize and compare the concept of human equality that is presented in the Code of Hammurapi, the Roman Twelve Tables, the Code Napoleon, and the Hindu religion." Several questions contained a date or date range, as did question 2-7: "Who was king of England in 1628 and what significant democratic event occurred?" However, dates were not usually mentioned in the subject index. *Dates* could be considered to be either a separate category, or a specific instance of *indirect* access.

Table 4-3 categorizes these questions on the dimensions of question form (i.e., management of information such as in multiple or comparison questions) and question content (i.e., search requirements based on dates or multiple attributes). All of the questions appear in Tables 4-4 and 4-5. As a descriptive device, Table 4-3 indicates an approximate distribution of the question sample in this possible question space. Not all combinations are represented and question generation and selection was biased toward simple rather than complex questions, toward single questions with one attribute rather than multiple questions involving indirect search and analogies. This partitioning will not be used in any later rigorous analysis, hence, we need not concern ourselves with problems of erroneous classification and completeness or disjointness of the question categories. For example, one might want to include ideas from the reasoning processes necessary for answering cause-effect or "how" questions, or, on the basis of the answer required to further classify questions: fact, hypothesis, or opinion.

Table 4-3
A Classification of Questions Used In the Experiment

Search Attributes	Question Form			
	Single	Multiple	Comparison	Analogy
Simple	1, 10, 12	6, 16		
Multiple attributes	3	9		
Multiple access		2, 15	5, 13, 17	14
Date access	4	7, 19		
Indirect access	8, 18, 20	11		

Questions were initially generated by selecting simple questions from the ends of sections and more complex questions from the ends of chapters in the textbook. Other questions originated from passages in the text and entries in the subject index. Later, the questions were refined so that members of a pair of questions were similar, and that different pairs might require different search tactics. Each question could be answered by using a combination of finding terms in the subject index, browsing section headings, and reading and paging through parts of the books. As mentioned earlier, pictures, diagrams, timelines and maps were not included in either the paper or the dynamic books, although they could have been useful for certain of the questions presented.

These lists were designed to be equivalent in difficulty. Pairs of questions were created that were somewhat equivalent in content, difficulty, and in the kinds of strategies needed to find suitable information to answer them. A computer-generated sequence of random numbers was used to randomize the order of these matched pairs. Then two lists were created by randomly assigning members of each pair to consecutive positions in either list. Table 4-6 illustrates the process for four pairs of questions.

Table 4-4
Question List 1

1. Where did the Etruscans come from and whom did they conquer?
2. What methods of writing were developed by the Phoenicians?
   What methods of writing were developed by the Maya?
3. What important effect did the Hundred Years' War have on French government?
4. Describe an important change in warfare that occurred in Europe betwen 1450 and 1750.
5. Name one way in which Buddha disagreed with the teachings of Hinduism.
6. What architectural idea did the Romans probably borrow from the Egyptians?
   Where else did this idea appear over a thousand years later?
7. Who was king of England in 1215 and what significant democratic event occurred?
8. What was the first country to give women the same voting rights as men?
9. Name two Romantic composers and one neo-Romantic composer.
10. Name an important tool that was probably invented by the Cro-Magnons.
11. When and where did farming probably begin in the Americas?
    What became the most important grain crop?
12. Give two reasons for exploration by Europeans in the latter 15th and early 16th centuries.
13. Name two features of feudalism that were the same in China, Japan and Europe.
14. What three legislative acts in Germany provided protection similar to that of Britain's National Insurance and Assistance program?
15. What probably started the War of the Spanish Succession? What was this war called in North America and which two countries fought there? Which treaty ended the war?
16. Name the three major rivers of China. Along which river did Chinese civilization first develop? Where was the Great Wall built?
17. Briefly summarize and compare the concept of human equality that is presented in the Code of Hammurapi, the Roman Twelve Tables, the Code Napoleon, and the Hindu religion.
18. After which Chinese dynasty did foreigners begin using the name "China?"
19. Who was leader of France in 1685 and what action occurred that had an significant effect on French religion?
20. What was a reason why the Roman Republic in 265 B.C. was able to achieve and keep their conquests?

Table 4-5
Question List 2

1. Where was the original home of the Bantu peoples? Name an area where they went.
2. What methods of writing were developed by the Chinese?
   What methods of writing were developed by the Inca?
3. What effect did the Thirty Years' War have on the power of the Holy Roman Empire?
4. Name a weapon introduced to early Egypt about 1750 B.C.
5. Name one way in which the creation account of the Yakima is similar to the creation accounts of the Africans.
6. Name two architectural ideas that the Romans probably borrowed from the Etruscans.
7. Who was king of England in 1628 and what significant democratic event occurred?
8. In what year did women gain the right to vote in Japan?
9. Name an Italian Renaissance composer and two Baroque period composers.
10. Name an invention that made navigation safer.
11. Name two Native American tribes which did not adopt farming.
    On what did they depend for food?
12. What two effects did the French Revolution have outside of France?
13. Name two results of large-scale irrigation which were similar in Mesopotamia, Egypt, and the Aztec empire.
14. What event in France was similar to the Education Act of 1870 in England?
    In what year did that occur in France?
15. What probably started the Seven Years' War? What was this war called in North America and which two countries fought there? Which treaty ended the war?
16. Name the two major rivers of India. Along which river did Indian civilization first develop? During which months of the year does the monsoon season occur?
17. Briefly summarize and compare the educational opportunities for women that were available in Greece, during the Epic Age of India, in the Roman Republic, and during the Renaissance.
18. What is the origin of the name "England?"
19. Who was leader of France in 1801 and what action occurred that had an significant effect on French religion?
20. What was a reason why the Roman emperors objected to Christianity?

Table 4-6
An Example of Question List Generation

Original List	Randomized List	Question List 1	Question List 2
1A, 1B	2A, 2B	2A	2B
2A, 2B	4A, 4B	4B	4A
3A, 3B	3A, 3B	3B	3A
4A, 4B	1A, 1B	1A	1B

All students used the same two lists of questions. Questions were presented in a single order with no provision for going back to a previous question once it had been answered or skipped. There was an overall time limit of two hours for each list of twenty questions. Figure 4-5 shows the instructions about questions and answers that were given to students.

Pilot Study

Several early volunteers helped ensure that the dynamic books were indeed usable and bug-free, that data collection worked, and that the number and types of questions were reasonable. There were two adults, and one high school senior in that preliminary study. Manuals were constructed for Books A, B, and C that describe the operation of the browser for each. These are reproduced in Appendixes A, B, and C, respectively.

Seven volunteers participated in the pilot study: one adult, and six 7th-9th grade students. To orient each participant, the experimenter used the manual as a guide to illustrate the system capabilities, and helped them to answer three sample questions:

1. List four things that the concept of culture includes.
2. In England in 1689, what parliamentary act increased religious freedom?
3. Compare the disintegration of the Han Empire with that of the Roman Empire.

They were then left alone for 2 hours to complete a list of twenty-four questions. When they were finished or when two hours had elapsed, they were given a brief questionnaire to fill out. On each day, they were given the same general questionnaire about the questions and about that day's book, but on the second day, they were also given some additional questions about which book they would prefer to use.

One result of the pilot study was to shorten the list of questions from 24 to 20 questions for the 2 hour period; in other words, a student would have an average of 6 minutes rather than 5 minutes to answer each question. In the pilot study, students were told that one of the questions in each list had no answer, that no information could be found for it in the book (the book had no information about the American Civil War or about early American presidents). As a result, when students were confronted with a difficult question, they often decided that it must be the unanswerable one and skipped it too readily. Because there were many questions that could be

Information about Questions and Answers

You will be presented with 20 questions. There is an overall time limit of two hours, but there is no fixed time limit for each question. One rule of thumb is that, on the average, questions will take you about 6 minutes to answer, a few less, a few more. If you find yourself spending too much time on a particular question, say more than about 10 minutes with no luck, you might think about going on to the next questions; on the other hand, don't give up too quickly if you're making progress. However, once you skip a question, you can't go back to it later. To help you keep track of the time, the Commands area shows the elapsed time for the current question and the total time for all questions so far; questions in the Question area are numbered from 1 to 20.

Answers can be short and can consist of phrases rather than complete sentences. Don't worry about minor spelling mistakes or punctuation errors. Some questions may have several parts -- be sure to answer them all. When using the paper textbook, you should include a few supporting page number references as part of your answer and surround them in brackets [ ] or parentheses ( ), for example, [12, 15].

Some of the questions will be easier than others. Information that will enable you to answer the questions may be found in the textbook. You can and are encouraged to use common sense and previous knowledge about world history in order to figure out the right subject terms to try or the right places to read, for example, by thinking of a related or more general subject term, or a person or event that happened at the same time. However you shouldn't just guess at the answer without finding some supporting information in the text.

Please don't discuss the questions or your answers with any of your classmates until the entire experiment is finished, around the beginning of June. Thanks for your cooperation.

Call me at 4388 if you have any problems.

Figure 4-5. Introductory Information Given to Students

considered difficult, at least initially, several questions were probably skipped quickly as unanswerable. To reduce this bias and uncertainty, the unanswerable questions were eliminated. Thus, all questions in the actual study that followed had accessible answers, though some students still might not be able to find them. To compare equivalence of question lists, the latencies for correct answers were used to guide the equalization difficulty. One member of some question pairs was made easier or more difficult, some questions were deleted entirely, and a few new questions were added. Although the sample size was small and no formal statistical analysis was done with the pilot data, the fact that students with a minimum of training could answer most of the questions successfully within 2 hours using the different book versions provided was definitely encouraging. In the questionnaires, they expressed a strong preference for using the dynamic books again in a similar task.

Students

Sixteen students for the actual experiment were chosen from a single population: students from two eighth-grade history classes at Jordan Middle School in Palo Alto, California. Both classes had the same teacher and both were "vertical team" classes, a project that provided some alternative curriculum programs within the school. Students at Jordan in general, and in the vertical team in particular, were above average in academic ability and in their exposure to computers. From the questionnaire after the experiment, their computer experience could be classified as follows: two students had never used computers before, seven had played games or written simple programs on several occasions, four had played games or programmed more frequently, and three used computers almost daily. Participants were volunteers who obtained parental consent, and who were willing to attend both an orientation session and the two two-hour experimental sessions during non-school hours. To ensure student attendance and to widen the appeal of the experiment to reach beyond those who would be willing to do anything if a computer were involved, they were paid $3.50 per hour. Eighteen students responded. One of these served in the pilot study, and one was unable to attend; of the sixteen remaining students, five were girls, and eleven were boys. Had there been 8 girls and 8 boys who volunteered, this could have added an additional factor to the analysis. The different groups were formed by random assignment of students.

Training

The sixteen students came for a one-hour preliminary orientation session to become familiar with the purpose of the experiment and with the different books they would be using. After Book A was demonstrated to all students, half of them practiced as a group with the computer and answered the sample questions used in the pilot study. In the meanwhile, Book B was demonstrated to the AB and BA students; later they practiced with Book A, while Book C was demonstrated to the AC and CA students. Students were asked not to reveal the details of any of the questions or the book they used until after the experiment was finished for everyone.

When students arrived for each day of the experiment, the general instructions (Figure 4-5) were read to them. The appropriate manual (Appendixes A, B, or C) was used as an instructional guide with the same three sample questions as before to refamiliarize them with the details of selecting questions, operating the appropriate book, and entering answers. The instructions and the manual were left with the students in case they needed to refer to them during the experiment.

The Actual Experiment

The experiment took place during May 1981. Aside from the inevitable complications arising from class field trips, vacations, injuries, and after school jobs and athletics, there were no serious disruptions. Usually two students came on two consecutive days after school: on one day, one student would use the Alto computer and Book A in one experimental room, and the other student would use the Dorado computer with electronic book B or dynamic book C in an adjacent room; on the next day, their roles were reversed. Students needed little additional training in learning to use Book A, especially if they had used the more complicated book B or C the day before. Students using Books B and C were given a 20-minute hands-on review of system use, with the student manual as a guide, and the three sample questions as exercises. After taking up to two hours to answer the twenty questions in the experiment, students took an additional ten minutes to answer the questionnaires. On only two occasions were there computer failures during the experiment: in one situation, the failure occurred on the first question, and because the machine could not be repaired immediately, the student was rescheduled for the next day; on the second occasion, the student was able to resume the experiment after a delay of only a few minutes.

Data Collection

Each of the three computer systems collected information from the student. The less sophisticated computer system associated with the paper book, Book A, collected only information about answers and times for each question. In addition to this basic information, the two systems for the dynamic books collected a more detailed protocol, including where the student pointed with the mouse on the screen, what subject terms the student typed or selected, and which sections or pages of the book were examined. This protocol can be used in various ways. It can be summarized into a list of the question, its answer, and the latency in seconds. More detailed information can also be identified and compressed somewhat to give a second-by-second transcript of what occurred; an example of such a transcript is given in Figure 4-6. In addition, the data file can be "replayed" through the computer system to give a real-time or speeded-up view of what the student was actually doing, similar to what a video tape of the screen would show, and can give a dynamic sense of the data.

Answers were graded by two judges as follows: a skipped question or totally incorrect answer received a score of 0.0; an entirely correct answer received a score of 1.0; a partially correct

answer received a score of 0.5. Although a finer grading system could describe the answers for questions with many parts more accurately, it would also make the task of judging less reliable. Students were identified by number and not by name or treatment group to avoid any bias. The judges agreed on almost all of the scores initially, and resolved any disagreements. The resulting latencies and correctness scores are summarized in Appendix D, and are used in later analyses discussed in Chapter 5.

Transcript Excerpts:

0:00:00	selected item 1 in Pane 1
0:00:01	question 1 displayed in Pane 2
0:00:02	moved mouse toward Pane 4
...	(more mouse movements)
0:00:10	typed culture in Pane 4
0:00:12	moved mouse to Pane 5
0:00:14	scrolled up 1 in Pane 5
...	(more scrolling)
0:00:18	selected item 5 in Pane 6
0:00:20	moved mouse to Pane 8
0:00:25	selected item 1 in Pane 8
0:00:40	moved mouse to Pane 3
0:00:55	typed h in Pane 3
...	(more characters)
0:01:30	selected item 2 in Pane 1
...	(more questions)

Summarized and Labeled as:

0:00:00	Commands: [selected] *start first question*
0:00:01	Question: 1. List four things that the concept of culture includes.
0:00:10	List of Subjects: [typed] *culture*
0:00:14	Subject Index: [scrolled up] 3 (for: 0:00:03)
0:00:18	Subject Index: [selected] *Culture, defined*
0:00:25	List of Titles: [selected] *Prologue - Prehistoric People...*
0:00:55	Answer: [typed] *housing, language, tools, education* (for: 0:00:30)
0:01:30	Commands: [selected] *end this answer* (for: 0:01:30)

Summarized Further as:

1. List four things that the concept of culture includes.
housing, language, tools, education
90 [seconds]

Figure 4-6. Sample Transcript for a Student's Answer

Chapter 5. Results

Protocol data collected by the system for Books B and C provide insights into the use of tactics and the possible interaction of tactics with interface designs of books. Student questionnaires yield additional information about interface design as well as student preferences. Finally, performance data summarized from all three books allow a limited comparison of student groups on the basis of correctness and latency.

In Search of a Model for Search

Specification and validation of a detailed model of search would be premature given our current state of understanding about search, and the limitations of the experiment. However, by examining the data, we can observe and classify some patterns of use, and make suggestions for the next set of explorations. For example, understanding which tactics students used successfully, used inappropriately, or failed to use although applicable, can aid in the better training of searchers. Tactics, as well as positive and negative evidence about the user interface, can suggest ways in which information sources such as dynamic books can be improved to augment rather than hinder the search process. Replaying a student data file can yield a "movie" of how a student actually used the electronic or dynamic book and what he saw on the screen at any given moment. If this were a dynamic dissertation, then the examples of student behavior presented below could be viewed by the reader as segments from a movie rather than left to conjuration from static pictures and dense prose. All of the data files were replayed to aid us in finding problems with the students' use of the books and in understanding the rationale behind certain patterns of search, especially those that were not obvious from reading the transcript.

In the sections that follow, we will examine instances of students' successful and unsuccessful search. This analysis of protocols can be structured from many points of view: from that of the user or that of the computer; and with respect to tactics, to browser features, or to the kind of questions to answer. First, we will examine several tactics: selecting among alternatives, utilizing the structure of the book, following subject references, and saving and returning to a subject or book location. These can be carried out differently in the electronic and dynamic books. Second, we will look at one question in detail to see the application of different tactics in its solution. Finally, we will offer some comments about the students, the book, and the browsers that do not fit conveniently under the earlier categories. Throughout, we will attempt to identify student errors of inadequate knowledge about and use of tactics, errors of inadequate training given to students in operation of the interface, and errors in the interface layout and implementation. In addition, we will look at the differences of search behavior when using the electronic book as opposed to the dynamic book, specifically in the provision and use of heading vs. page-oriented access, subject-pattern matching, and cross references. Appendix F, in addition, summarizes the questions, acceptable answers, subject terms that refer closely to parts of the answer, and subject terms that were tried by students using Books B and C.

A Simple Search

Each of the 16 students used either Book B or Book C to answer one list of 20 questions, giving us 320 separate protocols to examine. Roughly 18% of the protocols fall into a very simple pattern of behavior: type in a subject, select a subject heading, select an associated title or page reference, read some text, and enter an answer. Figure 5-1 illustrates the course of a simple search, with two minor variations: typing the subject in the wrong area, and successfully selecting a nearby sub-section of the book from the heading hierarchy. After student #1 (using Book C) discovered that *cro-magnons* had been typed in the wrong area (i.e., *Answer* pane), she erased it (indicated by <↑X>) and typed it again in the *List of Subjects* area. After selecting the term *Cro-Magnon humans* in the *Subject Index*, she selected the associated title reference to a section, selected the sub-section (*Tools*), and entered the correct answer. For this example and later examples, the reader may wish to refer back to Figures 4-3 and 3-5 to identify parts of the browsers for Books B and C, respectively.

Question: 1-10. Name an important tool that was probably invented by the Cro-Magnons.
Answer: [typed] *cro-magnons<↑X>* [erased]
List of Subjects: [typed] *cro-magnons*
Subject Index: [selected] *Cro-Magnon humans*
List of Titles:
[selected] *Prologue - Prehistoric People...>*
Cro-Magnon
Sub-Sections: [selected] *Tools*
Answer: [typed] *burin*

Figure 5-1. A Simple Search for Question 1-10

Selecting or Generating Parallel Alternatives

Students typically first attempted to probe the subject index with exact words and phrases from the question, thereby apparently using the tactic "S1.Specify -- To search on terms that are as specific as the information desired." When this did not correspond to a subject term present in the *Subject Index* or was not specific enough, various other tactics were then employed. For example, the user might sequence through a list of alternative sub-subject terms provided by the system or subject terms generated by the user himself. The sub-subject terms under *England* included events; the sub-subjects under *Native Americans* included a list of individual tribes. The user, after moving down in the subject hierarchy from *Native Americans* to instances of tribes (a combination of Bates' T2.Sub and S3.Exhaust tactics), might then select and inspect the references for successive tribes (thus using the T3.Relate tactic). Selecting multiple items from the *Sub-Subject Index* occurred in approximately 43% of the protocols.

Selecting from Explicit Lists

For example, in Figure 5-2, student #7 used Book C to answer a question about Native Americans who did not farm. In the corresponding search diagram in Figure 5-3, the primary book sequence is represented on the right as Book C's heading hierarchy rather than a list of

page numbers. Subject terms, listed on the left, refer to locations in the book, listed on the right. (For further interpretation of search diagrams, refer back to the description on page 15 preceding Figure 2-1.) Figure 5-4 shows a picture of the screen at the end of the question. Thus, Figure 5-2 shows the sequence of operations the student performed, Figure 5-3 shows some of the possible information space connections and transitions, and Figure 5-4 shows what the student finally saw on the screen. *Tribe* was not present in the *Subject Index* (the system presented neighboring entries centering alphabetically around *Tribe*: bounding entries were *Trianon, treaty of* and *Tribunes (Roman)*). *Native American* was not present exactly, so the student selected the plural term *Native Americans* from the Subject Index. Neither *farming* nor *agriculture* were mentioned in the visible initial part of the *Sub-Subject Index*, and the student did not scroll to see if there were any related entries. Rather he selected the first sub-subject entry, *arrival of earliest.* Because the title refers to the start of farming, he might have assumed that it might also discuss people who did not farm. He selected the title and was presented with the corresponding sub-section of the book. He then returned to the *Sub-Subject Index* and selected the first tribe mentioned, *Bella Coola*, that referred to a sub-section containing information for the entire question. However, the student forgot to include in his answer what the people ate.

Question: 2-11. Name two Native American tribes which did not adopt farming. On what did they depend for food?	
List of Subjects:	
[typed] *tribe*	[term not there]
[typed] *native american*	[closest term is *Native Americans*]
Subject Index: [selected] *Native Americans*	
Sub-Subject Index: [selected] *arrival of earliest*	[first entry]
List of Titles:	
[selected] *Prologue-Prehistoric People...>*	
Development of Farm Communities>	
Two Birthplaces of Farming	
Sub-Subject Index: [selected] *Bella Coola*	[second entry]
List of Titles:	
[selected] *Cultures and Civilizations of...>*	
People Spread Out over the A...>	
Some Were Not Farmers	[a relevant sub-section heading]
Answer: [typed] *bella coola, eskimos*	[omitted fish]

Figure 5-2. Selection of Alternatives from the Sub-Subject Index for Question 2-11

The same pattern of repeated selection of alternatives from the *Sub-Subject Index* was used by student #7 for questions 2-13 ("Name two results of large scale irrigation which were similar in Mesopotamia, Egypt, and the Aztec empire") and 2-14 ("What event in France was similar to the Education Act of 1870 in England? In what year did that occur in France?") also. Although the apparent use of this tactic is the same, the three overall information-seeking goals are somewhat different, however. For question 2-11, the student began to select independent entries in an attempt to find a discussion of farming or a relevant tribe. In question 2-13, student #7 selected *Irrigation* in the *Subject Index*, and then *Aztec, Egyptian*, and *in Mesopotamia* in the *Sub-Subject Index.* Here the three entries must be compared (possibly referred to more than once). Similarly, several entries must be related in question 2-14, but order is important: the student

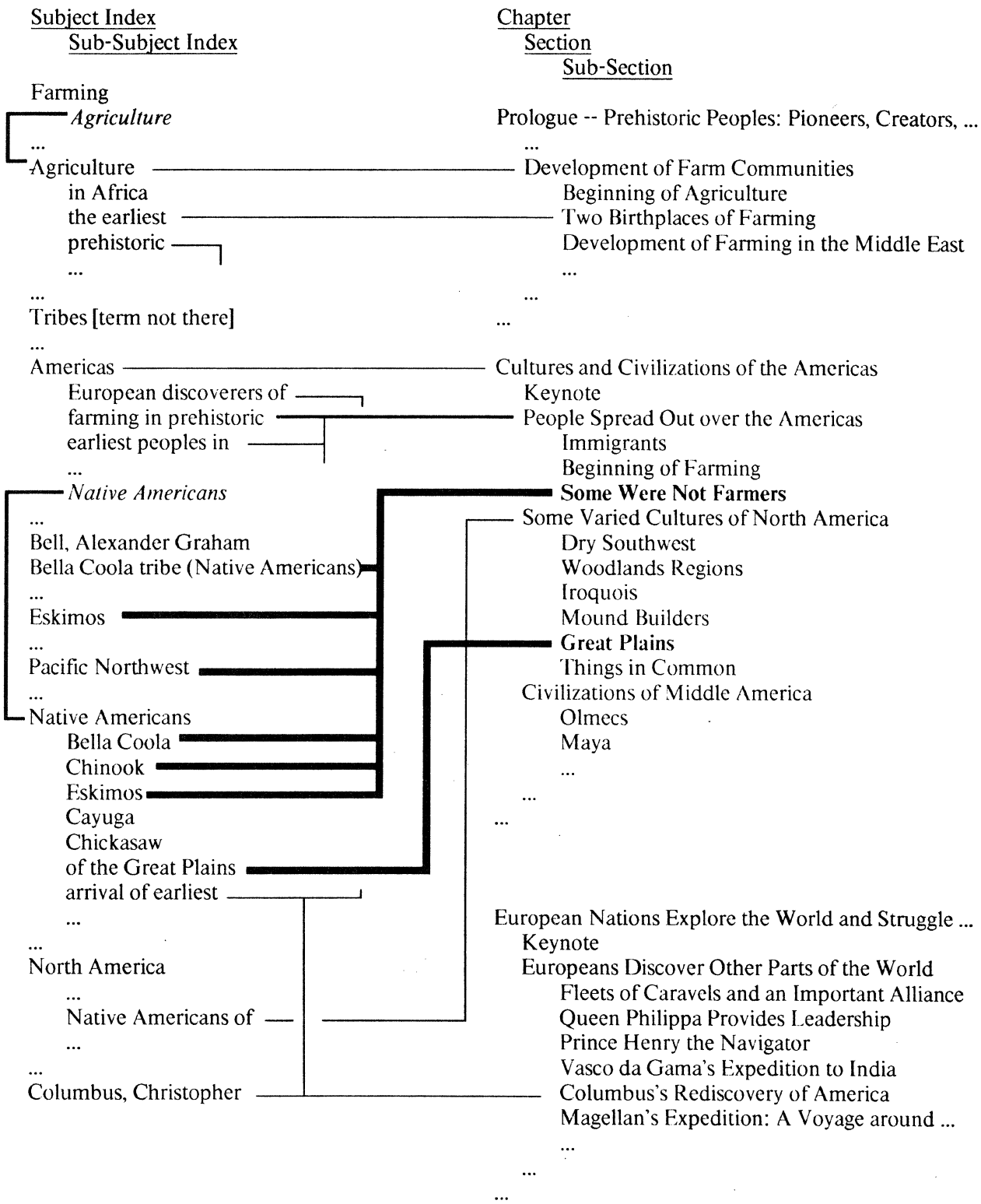

Figure 5-3. A Search Diagram for Question 2-11

start next question end this answer 0:01 (this question) 0:01 (all questions)	**11. Name two Native American tribes which did not adopt farming? On what did they depend for food?**

Answer

bella coola, eskimos

tribe native american	Nationalization Nations, battle, of the Nations, the origin of Native Africans **Native Americans** NATO Navigation Act of 1651 (Brit Navigation improvements Nazis Neanderthals	arrival of earliest **Bella Coola** Cayuga Chickasaw Chinook Choctaw Creek Delaware Eskimo Fox

Cultures and Civilizations of...>People Spread Out over the A...>Some Were Not Farmers

Cultures and Civilizations of the Ame EUROPE IN TRANSITION: FRO Christianity and Feudalism in Europe Rise of Trade, Towns, and Nations New Ways of Thinking Change Euro	Keynote **People Spread Out over the Americas** Some Varied Cultures of North Amer Civilizations of Middle America Aztec Empire	Immigrants Beginning of Farming **Some Were Not Farmers** Check on Your Reading

Some Were Not Farmers

Not all early American peoples adopted farming. Agriculture was impossible in Arctic regions, for example. People there--now known as Eskimos--lived mainly off walrus, seal, and certain kinds of fish. As was the case with other early **Americans**, their ways of living reflected their environment. They dressed in sealskin clothing, made tools of bone, and learned to make bone frameworks over which they stretched sealskins to fashion boats. They used blocks of snow and ice, an abundant resource, to construct shelters known as igloos.

Other non-farming peoples lived in the Pacific Northwest. It was easier for them to live off the abundant fish than to plant crops. Such tribes as the **Bella Coola** of British Columbia and the Chinook of Washington gathered halibut, salmon, cod, and other fish from rivers and the Pacific Ocean.

The Pacific Northwest region had a thick forest of firs, redwoods, cedars, and other trees. Cedar was especially useful. This durable wood is fairly easy to work with stone tools, the only kind most early **Native Americans** had. Pacific Northwest people felled cedars with stone hatchets and fire, and built large boats, some sixty or more feet long. In these boats they fished in the Pacific and also hunted for whales, subduing those huge creatures with stone-tipped harpoons.

Cedar was also a valuable resource for building. People of the Pacific Northwest made posts and planks from cedar logs for building houses. Such logs also furnished raw material for totems, logs carved into human and animal shapes and placed upright in the ground.

Americas	*Agriculture:prehistoric* *Americas:earliest peoples in* *Americas:farming in prehistoric*	*Bella Coola tribe (Native American)* *Chinook tribe (Native American)* *Eskimos*

icans:Bella Coola
icans:Chinook

Figure 5-5. Book C: A View of the Browser for Question 2-11

should first select *Education Act of 1870* under *Education* so that he knows what to look for (the introduction of compulsory education) when later examining *Education:French.*

Other examples of explicit lists were specific events grouped in the *Sub-Subject Index* under *England* or *France*, and "changes in warfare" associated with different wars under *Wars.* This strategy appeared to work well for date-oriented questions. For comparison questions, students could have constructed their own list of subject terms or title (or page) references and then selected items from this list, but as we will see later, this was not really necessary.

Students sometimes cycled through a list of old, unsuccessful subject terms several times (in the *List of Subjects* or *Subject Index*) rather than try something different. For example, in looking for information about French government, some students examined all subject headings beginning with "French," and only later, if at all, looked under "France." Training in the application of a term tactic, such as "T7.Fix" or "use nouns instead of adjectives," could help them break this cycle. Their success in subject access also suffered from taking phrases too literally or ignoring essential content words. For example, in question 1-14, one student found no subject entry for *Britain's National Insurance and Assistance* but then failed to look for *National Insurance and Assistance*, a tactic related to S3.REDUCE. Similarly, in answering question 2-3 about the Thirty Years' War and the Holy Roman Empire, students occasionally omitted *Holy* and thus located information about the *Roman Empire* instead.

Several sources contributed to errors in using lists in the *Sub-Subject Index.* Students forgot to access remaining alternative terms or chose terms in alphabetical order rather than based on content -- these are examples of tactical errors. Long lists whose last elements had to be scrolled explicitly into view, or whose elements disappeared at the right edge of the screen are examples of errors in screen layout, that could possibly be compensated for by better training. Modifying the browser to emphasize unreferenced *Sub-Subject Index* terms (as was done in the *List of Subjects* and *List of Titles*) might have encouraged students to access terms in a different order.

Generating Alternatives

When a subject term failed to be found, students often tried terms based on other words in the question. Less frequently, the student generated alternatives for the same term. Applications of "Idea Tactics" or "Term Tactics" could alter the course of a search by suggesting new terms related to the original question or to current terms. It was clear that the repertoire of these tactics, for most students, was limited, but on five occasions, students were able to generate terms for "English kings" or "voting." For example, in Figure 5-5, student #15 using Book B generated alternatives to voting, assuming that the answer to the question perhaps would be America. Other examples are given in a later section on answering a date-oriented question. Appendix F contains abbreviated search diagrams and a summary of the kinds of terms students tried for each question.

Question: 1-8. What was the first country to give women the same voting rights as men?

List of Subjects: [typed] *American Constitution*	[term not there]
Subject Index:	
[selected] *Amin Dada, Idi*	[a selection error or intentional?]
[selected] *Americas*	
Sub-Subject Index:	
[selected] *Spanish-Portuguest rivalry for*	
[scrolled] 6	
[scrolled] -3	
List of Subjects: [typed] *Constitution*	[term not there]
Subject Index: [selected] *Constitutional monarchy*	
List of Pages: [selected] 374	
List of Subjects:	
[typed] *voting rights*	[term not there]
[typed] *Ammendments* [sic]	[term not there]
Subject Index:	
[scrolled] 4	
[scrolled] -16	[scrolled backward to Amendments?]
[scrolled] 5	
[selected] *American Revolution*	
List of Pages:	
[selected] 351	
[selected] 360-364	
List of Subjects: [typed] *Woman rights*	[term not there]
Subject Index: [selected] *Women*	
Sub-Subject Index:	
[scrolled] -12	[top of list was already in view]
[scrolled] 18	
[selected] *rights of modern*	
List of Pages: [selected] 631	[discusses human rights in general]
Page Index:	
[selected] 630	[other contemporary problems]
[selected] 629	[modern music]
[selected] 630	
Sub-Subject Index: [scrolled] 24	
List of Pages: [selected] 631	
Answer: [typed] *America*	

Figure 5-5. Generating Related Alternatives for Question 1-8

Using a Pattern to Generate a List

Students using Book C could generate a list of alternatives by typing in subject patterns. This was presented briefly in the training sequence as a technique to be used only after they had tried more straightforward probes since the time cost was high: the system could take up to 60 seconds to search the index completely. Students used it notwithstanding (8% of the protocols); with more training, they could have avoided many of their tactical and interface errors. They sometimes specified too complex a pattern, e.g., **1450 and 1750**, rather than realizing that a simpler pattern would turn up at least the same information with less chance of failing entirely (the tactic of using a simpler pattern is analogous to "S3.Reduce -- To minimize the number of elements of the query in the initial search formulation"). A few students tried a pattern search too soon, e.g., **Seven Years' War**; the more direct term, *Seven Years' War*, not only is faster, but also positions the subject index to that region of the alphabet -- the pattern, especially if

misspelled (e.g., the apostrophe omitted) or too complex, may yield nothing. Several students entered a pattern that would have been successful, e.g., **Thirty Years' War**, but they aborted it too soon when it seemed to take too long and they saw no results.

In Figure 5-6, student #7 attempted several patterns in Book C to answer the question "Who was king of England in 1628 and what significant democratic event occurred?" Figure 5-7 represents part of the possible search alternatives. First of all, *king* did not occur alphabetically in the *Subject Index*. The first pattern **1628** did not yield any results because there are no subject terms such as *Petition of Right (1628)*. The second pattern, **king of england**, yielded a long list of kings including *Charles I, king of England*. Student #7 then sequenced through these in non-alphabetical order, and apparently kept track of kings already tried because only Henry VII was accessed twice in a sequence of 12 kings selected; he may have been helped by the appearance in the *Subject List* of as-yet-unreferenced subjects in **boldface**. This latter was a feature mentioned in the student manual but not explained to students because many lists of title or page references are short and easily managed. The student was eventually successful with his brute force approach of examining all English kings, but could have answered the question more quickly by selecting alternative sub-subjects for *England* (which he rejected earlier), or by more careful exploration of Book C near the kings he selected. For example, the first king, Charles II began his rule in 1660 after Cromwell died, but the student did not select this part of the book and examine parts earlier in the heading hierarchy (organized roughly by time). A little later in the sequence, he selected James I, Charles I's father, who ruled until 1625, and examined the corresponding part of the book, but did not go forward in the heading hierarchy to the next sub-section or section.

Question: 2-7. Who was king of England in 1628 and what significant democratic event occurred?
List of Subjects:
  [typed] *king* — [term not present]
  [typed] **1628** — [aborted; matching terms not present]
  [typed] *England*
Sub-Subject Index: [scrolled] 26
List of Subjects:
  [typed] **king of england**
  [scrolled] -8
  [selected] *Charles II, king of England* — [no title selected]
  [selected] *Edward VI, king of England*
List of Titles:
  [selected] *European Nations Explore the ...>*
    Power Struggle is Stepped Up...>
      Queen Elizabeth I Leads a Strong England
...
List of Subjects: [selected] *Charles I, king of England* — [12th king selected]
List of Titles:
  [selected] *Representative Government Gro...>*
    Parliament Disputes the "Div...>
      Charles I is Compelled to Accept the Petition of Right
Answer: [typed] *Charles I, no taxes could be inposed* [sic] *without the consent of parliament*

Figure 5-6. Selecting Alternatives Generated by a Pattern for Question 2-7

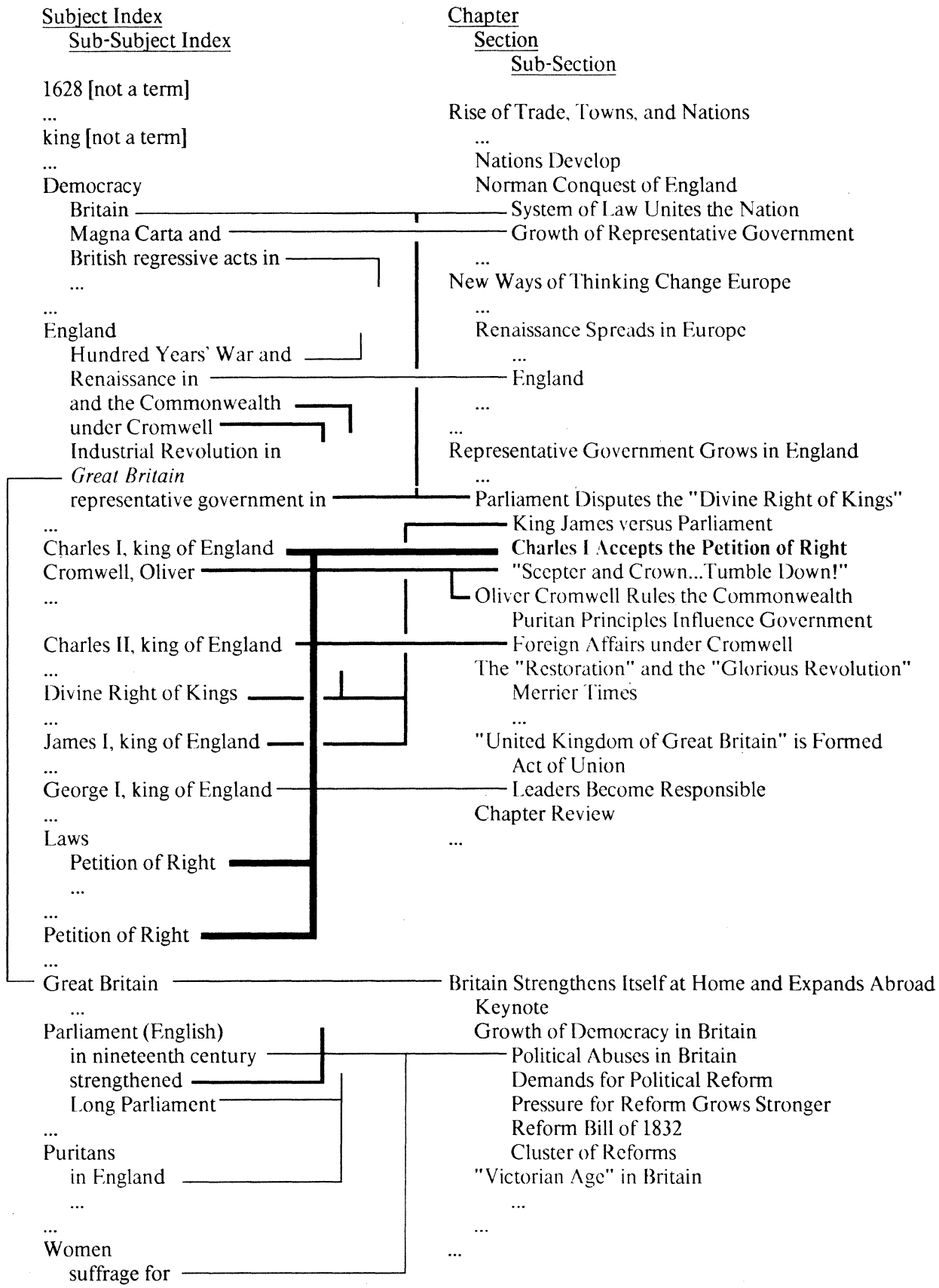

Figure 5-7. A Search Diagram for Question 2-7

In comparison, students using Book B had no access to subject pattern matching. For the same question, student #8 accessed several alternatives under *England*, tried *king* and *1628* as terms, started generating different names of kings (*george* and *james*), and found the answer about Charles I several pages after James I. This sequence took 4-1/2 minutes in comparison to 10 minutes for student #7.

Thus, although the pattern match strategy can be helpful, the specification of the pattern, and decisions about how to make use of the results need to be taught more thoroughly with more training examples. Not having access to a feature may be better than using it badly. Errors related to use of the interface include extra spaces and misspelled terms that the system should be able to detect and report. Showing progress of the pattern match (the system's current location in scanning the index) might help the student to make a more intelligent decision about when to abort. Finally, the resulting alphabetical list of terms is not always the most useful. In a system with more semantic information about persons, the user might like to see the list of kings sorted by another attribute, for example, presented in order of date of birth.

Accessing the Book Through its Order

When a subject term did not refer the student to exactly the right place, one alternative was to return to the *Subject Index* and try another subject term. However, if the desired information was close in either content or time to the current information, another approach was to look nearby in the book itself, using either page numbers in Book B or the nested headings of Book C. This accessing of one or more neighboring sub-sections or pages occurred in approximately 25% of both B and C protocols.

In questions involving dates, as in question 2-7 above, students successfully sequenced forward or backward in the book from a nearby date to the target date. Others sometimes continued looking through consecutive parts of the book even though the dates mentioned in that part of the book were centuries away from the desired date. The fact that the order of the book was strongly related to time and that time changed slowly from page to page (or section to section) was left for students to discover, or remember from previous experience with history books. Conscious awareness of this order is necessary to exploit it as a "File Structure" tactic (because of her domain, Bates did not identify page and heading access as tactics under File Structure).

Page Access

Students using Book B tended to read one page after another rather than skipping ahead a few pages at a time to locate information more quickly. If the question asked for some results of the French revolution, and the subject entry read "*France:revolution in,* 366-376," one might be better off searching the pages in reverse order because the "results" might occur near the end of the exposition. No one used a binary search technique on pages numbers to locate dates (is the desired date in the first half or second half of the book, first quarter or second quarter, and so on?). When a subject term yielded page references that did not seem relevant, students often

skipped the remainder of a page range or the other references in the *List of Pages*. Sometimes, of course, this was the right thing to do, and at other times, premature.

Figure 5-8 presents an example of a student's successful use of a sequential page access tactic, on the same question as in Figures 5-2 and 5-3 earlier. Student #6 scrolled the *Subject Index* rather than type a term such as *Native Americans* or *Americas*. Instead of selecting a sub-subject category such as *Americas:farming in prehistoric* or *Americas:earliest people in*, the student selected the cross reference *Native Americans* but did not add it to the *Subject List*. *Americas* as a subject heading refers to an entire chapter: pages 216-232. The student then began accessing these pages sequentially and found the answer on the third page.

Question: 2-11. Name two Native American tribes which did not adopt farming.
On what did they depend for food?

Subject Index:	
[scrolled] 72	[scrolled from *Aahotep* rather than typed]
[selected] *Americas*	
Sub-Subject Index: [selected] *Native Americans*	[a cross reference, not added]
List of Pages: [selected] 216-232	[page 216 was selected]
Page Index:	
[selected] 217	
[selected] 218	
Answer: [typed] *Bella Coola and Chinook, Fish*	

Figure 5-8. Sequential Page Access Tactic for Question 2-11

A small change in the design of the *Page Index* could have encouraged the skipping of pages as well as remedied another problem. The *Page Index* contained the current page number and the immediately preceding and succeeding page numbers, in addition to the page number of the first and last pages of the book, i.e., 1, current–1, current, current+1, 633. Pages 1 and 633 were included to indicate the legal minimum and maximum page numbers (in retrospect, this purpose could have been fulfilled by the scrollbar) as well as to make it easy to go to the end or beginning of the book without typing a page number. The latter goal was not achieved in use -- instead the capability proved to be a source of potential error because occasionally students accidentally selected 633 instead of current+1. Unless the user typed a page number in the *List of Pages*, this design constrained the user to sequence through pages one at a time in the *Page Index*. Thus, a simple change in the design of the Book B *Page Index* to current–2, current–1, current, current+1, current+2 would avoid drastic changes in context as well as allow for skipping of two pages at a time. Of course, more than five lines could be included, it could be biased in the forward direction, or other page numbers included to suggest a search tactic. Time spent on major improvements to the *Page Index*, however, might be better used to examine whether browsing hierarchical headings (such as in Book C) might be a superior way to survey content or a timeline to access dates. After all, page numbers are not directly related to history, only to a particular printed version of it.

Hierarchical Access

In comparison to Book B, a student using Book C who selected the same subject term, *Americas*, would have seen the chapter entitled *Cultures and Civilizations of the Americas*. If he had then selected the first section, *People Spread Out over the Americas*, the sub-section heading, *Some Were Not Farmers*, would appear.

A few students using Book C skipped through chapters a section at a time, and in one case, selected a neighboring chapter. For the most part though, these smaller, "named pages," i.e., sub-sections, were accessed in a sequential order at the lowest level, not utilizing the higher levels of the hierarchy of headings. Depending on the quality of the headings, sections and sub-sections could be skipped over without actually selecting text to be displayed, and depending on the quality of the section introductions as summaries, some detail could be more quickly displayed than in Book B, in which the entire page was displayed. Title references that contained chapter, section, and sub-section headings should have been more useful than page references containing only a page number. These former enabled the student to prioritize access to a list of many titles and to skip less relevant titles. In Figure 5-9, student #7 switched to the chapter on Egypt that followed the chapter containing information about Mesopotamian weapons, then followed the hierarchy to the correct sub-section.

Question: 2-4. Name a weapon introduced to early Egypt about 1750 B.C.
List of Subjects: [typed] *weapon*
Subject Index: [selected] *Weapons*
Sub-Subject Index: [selected] *ancient Mesopotamian*
List of Titles:
[selected] *Interacting Civilizations in...>*
Newcomers Build Empires>
More Conquerors and New Technology
Chapters: [selected] *Egyptian Civilization in the Nile Valley* [the next chapter]
Sections: [selected] *Egyptians Build a Civilization*
Sub-Sections: [scrolled] 3
[selected] *Time of Disorder Was Followed by the Building of an Empire*
Answer: [typed] *horse drawn chariots*

Figure 5-9. Selecting Chapters, Sections, and Sub-Sections for Question 2-4

Student #12 started with the same strategy for question 2-4, but selected many sections in the chapter containing the first title and failed to find information about Egypt. Later, for question 2-7 (see Figure 5-10), student #12 was successful in browsing backwards and forwards in the hierarchy at a section level, once he had located information nearby in time. (Note that his search can be related to earlier Figures 5-6 and 5-7.) On similar questions, it is apparent that Book C students had more trouble going backward in the hierarchy than going forward when changing levels was involved; it may have been more confusing to select the previous section and then its last sub-section than to select the next section and its first sub-section.

Perhaps with better training of students and additional types of questions, some clearer advantages and disadvantage between page numbers of Book B and the heading structure of

Question: 2-7. Who was king of England in 1628 and what significant democratic event occurred?
Subject Index:
[scrolled] 47
[scrolled] 58
List of Subjects: [typed] *englla* [sic]
Subject Index: [selected] *England*
Sub-Subject Index:
[scrolled] 22
[scrolled] -21
List of Subjects:
[typed] *king*
[selected] *englla*
Subject Index: [selected] *England*
Sub-Subject Index: [selected] *under Cromwell*
List of Titles:
[selected] *Representative Government Gro...>*
Oliver Cromwell Rules the Commonwealth
Sections:
[selected] *Keynote*
[selected] *Geography and History Are Closely Related*
[selected] *Parliament Disputes the "Divine Right of Kings."*
...
[selected] *Oliver Cromwell Rules the Commonwealth*
[selected] *Parliament Disputes the "Divine Right of Kings."*
Sub-Sections:
[selected] *"Scepter and Crown. . .Tumble Down!"*
[selected] *Charles I Is Compelled to Accept the Petition of Right*
Answer: [typed] *Charls* [sic] *the first,*
Text: [scrolled] 2
Answer: [typed] *the petition of right*

Figure 5-10. Selecting Sections within a Chapter for Question 2-7

Book C could be found. The hierarchy is more powerful than a sequence of page numbers because content can be used to choose both among titles in the *List of Titles* and among neighboring parts of the book in *Chapters*, *Sections*, and *Sub-Sections*. However, the hierarchy is more complicated to use and potentially more confusing to a naive user. Headings, whether they appeared in the hierarchical structure of Book C, or as text on the page in Book C, could be useful both as information to answer a question ("Etruscans Conquer the Latins," "Civilization on the Yellow River") and also as clues about which sections to read in detail ("Alphabet," "Some Were Not Farmers").

Following Cross References

Cross References

If the subject index had contained many cross references (such as "Farming, see Agriculture"), using them in the system would have been more strongly emphasized during student training. Students had problems in utilizing the cross-reference information that did exist in the subject index. Cross references were represented as italicized terms appearing at the end of the *Sub-Subject Index*, for example, *Great Britain* (intended to indicate "see Great Britain") appeared

under the subject term *England*, while other sub-subject terms appeared earlier in England's list in a normal typeface (although all are shown here in italics for emphasis). When students selected these cross references, they often did not subsequently use the "add" button on the mouse to add the term to the *List of Subjects*. Perhaps they did not know that it was a cross reference or had forgotten how to add it. Several students selected a cross reference, but then typed it themselves in the *List of Subjects*, which implies that they recognized it as a cross reference. To successfully use a cross reference (as in the two successful protocols), a student would have to select the term, add it to the *List of Subjects*, then move the cursor to the *List of Subjects* and select the new term.

Multi-step operations such as this run the risk of failing because of an omitted or improperly executed step. Several possible modifications of this design come to mind: cross references could be indicated differently so that they would be more easily recognized; the student could ask the system for help about using cross references; "selection" of cross references could be redefined to perform the "add" operation also; a new operator, "cross refer" or "jump," could be added to the command repertoire of "select," "add," "mark," and "delete." This last option is analogous to adding a "move" operation to a text editor rather than simply using combinations of the more primitive operations, "insert," "delete," and "copy."

Figure 5-11 shows the successful utilization of a cross reference as well as movement deeper in the heading hierarchy of Book C. Student #13 selected *Americas*, followed this to the cross reference *Native Americans*, inspected the sub-subjects under *Native Americans*, and returned to

Question: 2-11. Name two Native American tribes which did not adopt farming.
On what did they depend for food?
List of Subjects:
[typed] *american*
[deleted] *american* [not really necessary]
[typed] *america*
Subject Index: [selected] *Americas*
Sub-Subject Index:
[selected] *Native Americans*
[added] *Native Americans*
List of Subjects: [selected] *Native Americans*
Sub-Subject Index: [scrolled] 24
List of Subjects: [selected] *america* [rejected Native Americans]
Subject Index:
[selected] *Amin Dada, Idi* [a selection error or intentional digression?]
[selected] *Americas*
Sub-Subject Index: [selected] *earliest peoples in*
List of Titles:
[selected] *Cultures and Civilizations of...>*
People Spread Out over the Americas
Sub-Sections: [selected] *Some Were Not Farmers*
Answer: [typed] *eskimo and bella coola.*
walrus, seal, and fish; and halibut, salmon, cod respectively

Figure 5-11. Following a Cross Reference for Question 2-11

Americas to select the subcategory *earliest people in.* He then selected the section title and then a sub-section under that entitled *Some Were Not Farmers.* For comparison purposes, Figure 5-2 presented an earlier example, and Figure 5-3 represented a search diagram for this same question.

Subject References

Students using Book C had an additional source of cross references available, displayed in the *Subject References* panes at the bottom of the browser. One student even successfully added a subject reference (though this was not necessary to answer the question). Subject references were intended to provide possible links from the *Text* to the *Subject Index*, especially in cases in which the student located information related to the answer, but did not know the proper subject terms to access, and in which the subject terms were not used in the text itself. In the search diagrams such as Figures 5-3 and 5-7, these would be represented by following the lines from the book on the right to the subject index on the left. These subject references were briefly explained in the training sequence and students were shown that they could scroll the lists of references and add these related terms to the *List of Subjects.* More training examples would be needed to define more clearly those situations where subject references would be helpful. The lists were inconvenient to use because few items were visible (and had to be scrolled) and subject phrases were truncated because of limited screen space (the *List of Subjects* did display terms that had been added in their entirety because it was wider). Their effectiveness as cross references was probably diminished also by the multi-step "select-add-select" operation referred to earlier.

The two questions with which students had the most trouble (1-8 and 1-14) could have been answered by using these subject references. Figures 5-12 (compare to Figure 5-5) and 5-13 illustrate hypothetical searches for these two questions by showing typical subject terms selected initially by students and how these could have led to the respective subject terms, *Suffrage:for women* and *Germany:social welfare in.*

Adding and Marking

Adding

Another way in which the user could save time and short-term memory is by adding the currently selected subject or subject:sub-subject combination to the *List of Subjects* for later reference (related to Bates' "Monitoring Tactics"). For one-time access to the subject index, this would be an unnecessary step, but for the user alternating between several different subject terms, this could be advantageous. The student might have typed "mes" to position the subject index to the vicinity of *Mesopotamia.* After selecting *Mesopotamia*, the student might then add it to the *List of Subjects.* After perusing a different subject, he could return to *Mesopotamia* by selecting it in the *List of Subjects*, which would not only position the *Subject Index* but also select the term because it matches exactly. Adding is even more advantageous when several selections are required, as in sequentially specifying compound terms such as *Mesopotamia:early civilization in* or in returning to a sub-section found in a chapter or section (for Book C).

Question: 1-8. What was the first country to give women the same voting rights as men?
List of Subjects:
[typed] *voting*
[typed] *women*
Sub-Subject Index:
[scrolled] 17
[selected] *rights of modern*
List of Titles:
[selected] *Contemporary Changes and Futu...>*
Challenge of Contemporary Pr...>
Extending Human Rights
Sub-Subject Index:
[scrolled] -5
[selected] *in Japan, after World War II*
List of Titles:
[selected] *Asia Undergoes Great Changes>*
Democracy Develops in Japan>
New Constitution
Subject References (Sub-Section):
[selected] *Suffrage:Japanese* [selection and access to cross reference]
[added] *Suffrage:Japanese*
List of Subjects: [selected] *Suffrage:Japanese*
Sub-Subject Index: [selected] *for women* [access to a related term under Suffrage]
List of Titles:
[selected] *Britain Strengthens Itself...>*
Britain and New Zealand>
New Zealand Introduces Advanced Legislation
Answer: [typed] *New Zealand in 1893*

Figure 5-12. Hypothetical Search using Subject References for Question 1-8

Question: 1-14. What three legislative acts in Germany provided protection similar to that of Britain's National Insurance and Assistance program?
List of Subjects:
[typed] *Britain's National Insurance and Assistance*
[typed] *acts*
[typed] *National Insurance and Assistance*
Subject Index: [selected] *National Insurance and Assistance (Britain)*
List of Titles:
[selected] *Power Struggles and a Search...>*
Events in Other European Cou...>
Great Britain Adopts Socialist Measures
Subject References (Sub-Section):
[selected] *Social welfare:in Britain* [selection and access to cross reference]
[added] *Social welfare:in Britain*
List of Subjects: [selected] *Social welfare:in Britain*
Sub-Subject Index: [selected] *in Germany* [access to a related term under Social Welfare]
List of Titles:
[selected] *Italy and Germany Form Nations>*
Independent Germany From 1871...>
Social Welfare
Answer: [typed] *sickness insurance act (1883), accident insurance act (1884)...*

Figure 5-13. Hypothetical Search using Subject References for Question 1-14

Adding, as did marking, occurred in roughly 1/8 of the protocols, mostly for comparison questions or questions with multiple parts. In some cases, the student may have used the add button inadvertently, intending to use the select button. Several students added subject terms to the *List of Subjects*, in anticipation of a later return, but then discovered that they did not need these terms. A different system, rather than rely on the student to explicitly add items, might automatically maintain a record (possibly in the *List of Subjects* and *List of Titles*) of the subjects and titles already inspected -- in other words, always add terms automatically. If the list became too cluttered, then the user might have to inspect the items in order to decide which ones to keep or discard. However, this editing operation would be done after the items had been added to the list rather than beforehand.

Student #3 planned a global strategy at the beginning of several questions in Book C by using *add* to save the exact subject terms. In Figure 5-14, she answered question 1-9 by first locating both subject terms necessary to answer the question (*Music:romantic* and *Music:neo-romantic*) and then accessing the text and typing in each part of the answer as she found it. Because this was a multi-part question and not a comparison question, though, adding was a luxury rather than a necessity. The *Sub-Subject Index* served the purpose of providing an explicit list. However, if she had approached the material through the terms *Neo-reomantic music* and *Romanticism*, which are not conveniently adjacent in the *Subject Index*, and had reason to return to them, creation of a list by adding would have made much sense.

Question: 1-9. Name two Romantic composers and one neo-Romantic composer.
List of Subjects: [typed] *music*
Sub-Subject Index:
[selected] *neo-romantic*
[added] *Music:neo-Romantic*
[scrolled] 26
[selected] *romantic*
List of Titles:
[selected] *Industrial Revolution Changes...>*
Industrial Revolution and the...>
Romanticism in Music
Answer: [typed] *Beethoven and Wagner were Romantic composers, and*
List of Subjects: [selected] *Music:neo-romantic*
List of Titles:
[selected] *Contemporary Changes and Futu...>*
Twentieth-Century Music Take...>
Styles of Music
Answer: [typed] *Richard Strauss was a neo-romanticist*

Figure 5-14. Adding Subjects in a Multipart Question for Question 1-9

Similarly, although comparison was involved in question 1-13 in Figure 5-15, student #3 could have used the *Sub-Subject Index* itself as a source for reselecting the terms *Feudalism:European*, *Feudalism:Chinese*, *Feudalism:Japanese*. However, this latter strategy makes the assumption that the initial subject terms are not identical and that all of the sub-subject terms are visible without scrolling. Her strategy would have worked equally well if the terms had been *Europe:feudalism in*, *China:feudalism in*, and *Japan:feudalism in*. Note also in Figure 5-15 that the student

inspected sub-subject terms several times, perhaps examining cursorily the number and content of titles. She also used the hierarchy in two ways: first, to go from a section to a sub-section *Development of Feudalism*, and second, to go from a sub-section to the containing section, probably to read the introductory section material, that does not itself have a sub-section heading.

Question: 1-13. Name two features of feudalism that were the same in China, Japan and Europe.
List of Subjects: [typed] *feaud* [sic]
Subject Index: [selected] *Feudalism*
Sub-Subject Index:
[selected] *Chinese*
[added] *Feudalism:Chinese*
[selected] *European*
[selected] *Japanese*
[selected] *Chinese*
[selected] *Japanese*
[added] *Feudalism:Japanese*,
[selected] *European*
[added] *Feudalism:European*
List of Titles:
[selected] *Christianity and Feudalism in...>*
People of Europe Seek Safety from New Invaders
Sub-Sections: [selected] *Development of Feudalism*
List of Subjects: [selected] *Feudalism:Chinese*
List of Titles:
[selected] *Civilization Spreads from the...>*
Chou Dynasty>
Government
List of Subjects: [selected] *Feudalism:Japanese*
List of Titles:
[selected] *Japanese Build a Civilization>*
Feudalism Emerges in Japan>
Shogunate Is Established
Sections: [selected] *Feudalism Emerges in Japan*
Answer: [typed] *Lords owned the lands and the peasants were expected to farm the lands turning in their crops.*

Figure 5-15. Adding Subjects in a Comparison Question for Question 1-13

Marking

Given the design of the experiment, marking was not necessary in the *List of Subjects*. Typing or adding a subject term to the *List of Subjects* caused it to remain "permanently" until an explicit "delete" command was used or the next question was selected (marked subjects and titles were saved for each question, but because students could not return to work on earlier questions in this experiment, the subjects and titles that they had marked were never restored).

Titles in the *List of Titles* could be marked. Titles could originate as a result of a selected subject, or be added later from the Title Index, from the *Chapter*, *Section*, and *Sub-Section* panes. Normally, titles were replaced whenever a new subject or sub-subject was selected. Marked titles were kept, however, and new titles added to the list. Page numbers in the Book B browser could be marked also. Some of the initial use of adding and marking could probably be classified as either practice or as error in using the "select" button on the mouse (the "add" button was on its

immediate right). In most uses of marking, the student did not later return to the marked page. In Figure 5-16, student #6 marked page 314 in Book B. Evidently, marking a page range did not work and the student added the current page number from the *Page Index* to the *List of Pages* and marked it. He then explored the erroneous subject heading *Roman Empire* rather than *Holy Roman Empire*, before returning to the marked page and continuing for several pages to find the answer.

Question: 2-3. What effect did the Thirty Years' War have on the power of the Holy Roman Empire?
List of Subjects: [typed] *thirty*
Subject Index: [selected] *Thirty Years' War*
List of Pages:
  [selected] *314-316* [314 selected]
  [marked] *314-316* [attempted]
Page Index: [added] *314*
List of Pages: [marked] *314*
Page Index: [selected] *313*
List of Subjects: [typed] *roman*
Subject Index: [selected] *Roman Empire, the*
Sub-Subject Index:
  [scrolled] 32
  [selected] *social conflict in*
...
List of Pages: [selected] *314*
Text: [scrolled] 21
List of Pages: [typed] *315*
Page Index: [selected] *316*
Answer: [typed] *weakened their power*

Figure 5-16. Marking a Page and Returning for Question 2-3

Student #11 located a likely source for the answer to question 1-14 at the beginning of the search under *Germany:social welfare* and marked page 456. During the rest of the search, although he failed to locate a subject term such as *Great Britain:social welfare* or *National Insurance and Assistance* to refer him to the analogous information about Britain, he did refer back to page 456 several times.

A Detailed Look At Question 2-7

An alternative view is to look at the different tactics applied in the course of answering a specific question, 2-7: Who was king of England in 1628 and what significant democratic event occurred? In the search diagram in Figure 5-7, the following subject terms refer directly to the sub-section containing the answer (heaviest lines in the diagram):

Charles I, king of England
Laws:Petition of Right
Petition of Right.

Knowing part of the answer in advance would make it trivial to find the information, but none of the students selected any of these terms, at least initially. One student later selected *Charles I, king of England* after obtaining a list of English kings (by asking for *king of England*).

However, the students could have also found the information by proceeding forward or backward from a neighboring page or sub-section to the correct page or sub-section. Medium-weight lines in Figure 5-7 connect the following subject terms to nearby places in the text:

Democracy:Britain
England:and the Commonwealth
England:under Cromwell
England:representative government in
James I, king of England
Parliament (English):strengthened.

As we will see, students were fairly ingenious at locating information that was adjacent in time to the information in this section. After trying specific words from the question, such as *king* or *1628*, as subject terms without success, they generated various descriptions to access this information more indirectly, for example, find some English king and see when he lived, or find some English event and see how it differs from the one specified in the question. Figures 5-6 and 5-10 earlier show several approaches to this question.

Thus, there were four parts of the question that could guide the search, each individually or in combination: a king (unknown), a date (1628), a country (England), and a significant event for democracy (unknown). The following sections will look at these approaches to the question in detail.

King

King was not directly accessible. As described earlier, student #7 used the pattern **king of England** successfully to generate a list of kings to choose from in Figure 5-6. After trying *king*, *1628*, and *England* and several of its sub-subjects without success, student #8 typed *george* and then *james* to find information preceding Charles I. This is another example of the student generating names within some possible list rather than having the system present or generate a list.

On a related later question (question 2-19), student #8 again used a similar strategy: *james, henry, nopleon, napl.* In a similar question about French kings (question 1-19), student #3 used the pattern **king of France**. Assuming some prior knowledge about when a specific king lived, specifically that Louis XIV reigned in France from 1643-1715, together with some knowledge about the names of kings, one could infer that someone named Louis XI may have reigned at an earlier time than Louis XIV and use this information to prune the search of a long list of similarly named kings. (Of course, Henry IV intervened between Louis XII and Louis XIII, but this doesn't violate the order.) In addition, knowing when Louis XIV ruled might be useful in locating the names of kings of neighboring countries who lived around the same time and who may have cooperated on peaceful ventures or clashed in wars.

1628

Several students tried *1628* as a subject term, but were unsuccessful because no subject terms began with 1628. The pattern **1628** was unsuccessful because no subject terms contained 1628 anywhere within the phrase. Typing **1801** was a successful strategy, however, on a related question (2-19) where *Act of Union of 1801 (Britain)* and *Concordat of 1801* occurred in the *Subject Index*. Although not useful as a direct subject term, 1628 is an important attribute for the student to keep in mind, especially to exploit the order of the book in reaching nearby pages or sub-sections by routes such as "King" or "England."

Subject Index entries such as *England:1600-1800*, *England:in seventeenth century*, or a time-oriented index such as a time-line would have been helpful. If the full-text search capability had been made available, it would have been possible to locate *1628* occurring in the text itself, in "They used his great need for money to force King Charles I to accept the Petition of Right. The Petition of Right (1628) was a landmark in the growth of democracy in England." However, if the number 1628 occurred frequently in the text such as for the date of a birth or battle, or a physical measurement, further specification may be needed to cope with the volume of information returned. Also, free-text search would not find implicit references to 1628 such as "...in 1627. The next year..." unless the user specified a list of dates or a date range.

England

Another dimension of question 2-7 was England. There were 25 sub-subjects to choose from, with about half of them visible at any time. Student #6 selected three of the initially visible subcategories: *England:Industrial revolution in*, *England:and the Commonwealth*, and *England:Irish conflict with*. The last two subject headings located the student on a page that mentioned 1649, 21 years and three pages after the correct page, but the student gave up at that point. Many students selected other events from England's history, *England:Hundred Years' War and*, *England:Renaissance in*, and *England:under Cromwell*. Many of the other sub-subjects, including *Great Britain*, a "see also" reference, were not selected at all.

There are no date clues in any of the *England* sub-subject headings, no explicit references like "1750" or "eighteenth century," and no implicit references to well-known events such as World War II. How then did the students' prior knowledge help them choose appropriate and reject inappropriate headings? *England:under Cromwell* was an especially good choice because Cromwell ruled after Charles I was executed -- perhaps the student knew this or guessed. However, after choosing this term, student #12 had some trouble using the heading hierarchy of Book C to go from that section to the earlier subsection containing the earlier date and answer. Although student #5 had horizontal selection problems (as will be discussed later), she answered the question in under 4 minutes (the fastest) using Book B. After selecting *England* and scrolling the subcategory list, she accidentally selected *Engels, Friedrich* in the subject index, then selected *England* and scrolled the subcategory list again before finally selecting *England:representative*

government in. (Slower students accessed more subject headings or neighboring text.) In a related question (1-19: Who was leader of France in 1685 and what action occurred that had a significant effect on French religion?), students did not select the term *France:in seventeenth century* perhaps because it was well-hidden in the long list of sub-subjects or because they forgot that the term "seventeenth century" refers to years beginning with "16" rather than "17."

Democracy

None of the 8 students selected *Democracy* or any of its subcategories for the question we've been discussing, 2-7 (although some of the other 8 students searching for the answer to the matching question, 1-7: "Who was king of England in 1215 and what significant democratic event occurred?" did select it). Had they selected *Democracy*, *Democracy:Great Britain* would have been their next logical choice, given that they had the additional knowledge that the country of England is on the island of Great Britain. The first eight also did not look under institutions that might be related to democracy such as *Parliament* or *Laws*, perhaps because abstract nouns are harder to manipulate than concrete ones involving people or events. However, for a related question about French religion (question 2-19 mentioned above), students not only used *Religion* as a search term, but student #5 also tried an instance of religion, *Catholic Church (Roman):in France.* In the earlier question about voting rights (Figure 5-5), student #15 similarly generated terms related to the subject matter; in that case, the terms "amendments" and "constitution" were related to the subject of "voting."

Other Kinds of Errors

Errors in the Subject Index

Errors in the *Subject Index* itself contributed to some problems (subject terms and page references were copied exactly from the published book). For example, *Spanish Succession, War of the* refers only to page 324, while *War of the Spanish Succession* and *Wars:of the Spanish Succession* refer to both page 324 and 360. A student who chose the first subject term would have trouble in finding the information needed to answer all parts of the question (1-15), but should not have been expected to try variations on the same term. *Christianity:in Roman Empire* and *Roman Empire, the:Christianity in* have a similar mismatch of page numbers. A different problem is that neither *Roman Empire, the:religion in* nor *Religion:in Roman Empire* refers to these Christianity references but both refer only to ancient religion. This might be an occasion to add another level to the subject hierarchy or to use more accurate terms such as *early religion in.* If an index is to contain such KWIC-like entries, a human indexer should create a single entry, i.e., *War of the Spanish Succession* and its canonical set of page references, and let a program handle the details of creating references derived from the original reference. This would not only guarantee that page references would be the same but also that parallel forms of terms would be included. For example, most wars are included in the subject index both by name and under *Wars*, but *Wars:Hundred Years' War* does not occur while *Wars:Thirty Years' War* does.

Several of the questions refer to the Roman Republic. There are two Roman Republics, one ancient and one modern. The first is referred to by the subject headings *Roman Empire, the:Republic of* and *Rome, Republic of,* while the second is referred to by *Roman Republic (of 1848).* One question explicitly mentioned "the Roman Republic in 265 B.C." which should allow the student to reject the term containing the modern date, but there should nevertheless be at least a cross reference in the subject index, such as "Roman Republic, see Roman Empire." Similarly, if *Farming* refers the reader to look under *Agriculture,* then a common term such as *Voting* should have a cross reference to the much less familiar *Suffrage.*

Errors in Answering Questions

Even when students found what appeared to be the answer to the question, they were often careless. When a question had multiple parts, they sometimes ended their answer after they had answered the first part only (although they were reminded in the training introduction to answer all parts). They sometimes stopped reading the current section or page too soon; in the question on Cro-Magnon technology, for example, students sometimes answered "knives" or "scrapers" from the first paragraph rather than continuing to search for "burin." It may be that they misinterpreted or omitted part of the original question, "Name an important tool that was probably invented by the Cro-Magnons," such as by substituting "used" for "invented." Perhaps they read the question correctly but inferred the wrong answer from the text. In questions with multiple attributes, students sometimes paid attention to some but not all of the details: for example, in question 2-9 about Italian Renaissance composers, a few students answered with an Italian Renaissance writer or an Italian composer from another period. In the questions about kings of England in 1215 and 1628, students sometimes answered with a king from a different country or of a different period.

An important part of the search process is not only locating correct information but also recognizing inappropriate or incorrect information. Student #11 answered question 2-7 that Cardinal Richelieu (of France) captured La Rochelle in 1628. Because this answer occurred using Book A for which protocols are not available, there is no information about which subject terms were used. If one stretches the interpretation of the original question, the answer can be seen to satisfy it weakly: the date is correct; breaking the power of the Huguenots at La Rochelle could be interpreted as strengthening the French government (an event with negative democratic consequences); Cardinal Richelieu was acting as king for Louis XIII; and France is a country strongly associated with England in many ways. The student may have incorrectly read the question at the beginning, paid attention to only certain key attributes such as "1628," neglected to check his answer carefully against the question, or perhaps knew that it was wrong but wanted to put something down without spending more time.

Seeing is not the same as careful reading, and carelessness led to some errors. In the matching question about democracy and an English king in 1215 (question 1-7 stated earlier), several students answered Philip Augustus, who was king of France in 1215. In that section of the book

(two pages after the Magna Carta), a military victory over John of England in 1214 is mentioned with some accompanying changes in government. Student #1 accessed the correct sub-section by selecting the subject heading *Edward I, king of England* (generated from the pattern **king of England**) but answered Edward I rather than John. John and the dates of his reign were mentioned at the very beginning of the section, followed by paragraphs about the Magna Carta that were written in terms of "the king," never mentioning John again by name, and finally by some paragraphs about Edward I, where **Edward** appeared in boldface because this sub-section had been accessed from that subject heading. Without scrolling the text, the student saw the following portions of excerpted text.

> John (**king** from 1199-1216), a son of Henry II, became **king** of **England** at the end of the twelfth century...In 1215, a group of barons threatened to attack the **king** if he did not assure them of certain rights. The **king** gave in and affixed his royal seal on a famous document known as the *Magna Carta*, or Great Charter. It limited the **king**'s powers ...
>
> At this time the Magna Carta represented only an agreement between the **king** and his great landowners. Nevertheless it became a landmark in the growth of democracy ...
>
> During the thirteenth century, **King Edward I (king** from 1272-1307) needed funds ...

The student answered "Edward I. a group of barons threatened to attack the king if he did not assure them of certain rights." The second part is correct although Magna Carta would be preferred and more succinct; the first part of the answer could be due to a combination of misleading highlighting (**Edward**), ambiguous references ("the king" might be confusing because two kings are mentioned in the subsection, even though Edward was introduced after these references), and inattention to constraints (John was king until 1216; Edward was not king until 1272). Student #15 answered King John but did not say what event occurred. Student #6 said that the king was the son of Henry II; this is partially correct but also ambiguous because Henry had several sons.

General Observations about Use of the Browsers

Mouse and Cursor

The replays showed that the cursor was used to focus attention on textual areas of the screen, even when it could not be used for selection. Many students apparently used the cursor to follow words as they read not only in the *Question* area, but more especially in the *Text* area where long pages or sections of the textbook appeared. Such behavior could indicate where the reader spent time in judging the relevance of a passage to the question and in deciding how to modify the search description. If such a level of analysis were desired, however, an eyetracker would provide a more reliable (though cumbersome) means to collect such data.

The students had surprisingly few problems in making selections with the mouse. They sometimes selected an item above or below the desired item, in for example, the *Subject Index*; but these vertical errors were most likely due to initial inexperience with the mouse and the extent of the neighborhood surrounding an item. The design of scrollbars may have contributed to some observed horizontal errors as well. For example, if the student were scrolling the *Sub-*

Subject Index, the scrollbar would appear on its left and partially overlay the pane for the *Subject Index*. If the student left the scrollbar area by intentionally or accidentally moving the mouse to the left (rather than to the right), the cursor moved into the *Subject Index* area. Selections on the same line as the desired item in the *Sub-Subject Index*, but still to the left of the dividing line between *Subject* and *Sub-Subject Index*, would occur in the *Subject Index*. In both the vertical and horizontal mis-selection cases, something irrelevant might appear and some time would be wasted in the student's regaining his prior place in the book. A more general solution than redesigning scrollbars would be to provide an "undo" facility for backing up to previous points in the search sequence.

Some adding or marking occurred on several occasions in panes when no item was selected. Because the "add/mark" button was next to the "select" button on the mouse, it is likely that the student intended to select but pushed the wrong button. After noticing that repeated attempts to select the item failed, the student finally found the select button. One simple design change would be to make all of the mouse buttons "select" buttons, and to provide the "add/mark" and "delete" functions on a screen menu.

Typing and Scrolling

Typing in the browser is normally directed to the area that contains the cursor. Occasionally, a student would type a subject term intended for the *List of Subjects* area, forgetting that the cursor was in the *Answer* area (where it is positioned automatically after each new question is selected). Similarly, after finding an appropriate answer in the *Text* area or after trying a last subject term, students would occasionally type text intended for the *Answer* area in the *List of Subjects* or *Text* panes. Students usually discovered this problem soon after they looked up from the keyboard to read what they had typed. The problem of typing initial subject terms in the *Answer* pane could be easily solved by automatically positioning the cursor in the *List of Subjects* after a question was selected. However, for the experiment, this would have represented a minor difference in browser behavior between Book A and Books B and C. Because most answers were short and students were told not to worry about minor spelling and grammatical errors, typing and correcting was not a problem. There was some unnecessary typing: students checked to see whether atypical subjects (such as the student's name) were in the subject index, and one student repeatedly watched to see how fast characters could be displayed and then erased.

Students scrolled the subject index much more than necessary. Perhaps they enjoyed watching the subject terms speeding by, or just did not realize how many subject terms intervened between where they were and where they wanted to be. Most students typed in subject terms or partial subject terms to position the index, since this had been explained to them as the preferred method in the training sequence. On several occasions, typed subject terms were preceded by spaces and this caused some minor confusion because the system did not ignore the spaces, and students, not realizing that, thought the term was not present. More extensive initial testing of the system might have found this flaw. Misspelling of subject terms was usually not a problem

because students then had the opportunity to examine neighboring alphabetic entries; however, misspelling of subject patterns for Book C, as in **king of emgland**, was more serious when not noticed because, again, no subject terms were returned.

Scrolling was more of a problem in the *Sub-Subject Index* area and in the *Text* area, the latter especially for students with Book B. If something was not visible on the screen, the student might forget to scroll up to see it. The book, of course, was written originally for the paper medium, and when transformed exactly to the video display, many sub-subject lists and pages or sections of text from the book did not fit entirely on the screen. Larger screens would help, but a better solution would be to write dynamic books and design browsers that incorporate spatial constraints and knowledge about the screen (or page) size. Other limits might be applied to the subject index, such as a subject having no more than ten further sub-categories (sub-subjects), but this should be dictated by psychological research rather than by the screen space of a particular implementation. To deal with the current long sub-subject lists, more entries might be added to the subject index, more levels added to the subject hierarchy (there are currently two), or scrolling augmented by search (the *Subject Index* is positioned alphabetically in this way).

Answers

In questions that asked for several pieces of independent information, found in separate parts of the book (e.g., Romantic and neo-Romantic composers), students sometimes typed in part of the answer before looking for the other part. In comparison questions that also involved several pieces of information, but pieces that must be compared (e.g., aspects of feudalism in several countries), students postponed any answer until they had examined most parts. As noted earlier, answers on a few occasions began to be entered in the wrong pane on the screen. Several times students selected *end this answer* and then realized that they had forgotten to answer part of the question, but at this point it was too late to add anything. Permitting students to return to previous questions would have eliminated this problem.

Questionnaire Results

Three questions on the questionnaire at the end of the experiment asked students to state a preference for the electronic, dynamic, or paper version of the book for three tasks:

1. I will be giving you a few more questions to answer. Which of the two "books" that you've used so far would you prefer to use again: the paper textbook or the electronic (dynamic) textbook? Why?
2. Which book would you prefer to use in answering a complex question involving many parts of the book? Why?
3. Which book would you prefer to use for reading an entire chapter? Why?

Given the small sample size, the results are not appropriate for a statistical analysis and will only be briefly described below. For answering more questions, 14 out of the 16 students preferred the electronic or dynamic book that they used in the experiment (they could not choose the other book because they had not seen nor used it) over the paper book and 1 student liked both; all

seven students in the pilot study preferred the electronic or dynamic books also (they were asked the first question only). For answering a complex question involving many parts of the book, 10 of the 16 students preferred the electronic and dynamic books. For reading an entire chapter, 12 of 16 preferred A, though 2 of the remaining students would use any book. Overall, most students said that they enjoyed using the computer for finding information. Table 5-1 summarizes the preference results for students in the B and C groups. Generally, students who used Book C tended to prefer the dynamic book over the paper book more frequently than did those students who used the electronic book, Book B. As the task changed from question-answering to reading, more B students preferred the paper book.

Table 5-1
Student Preference for Books in Three Situations

Situation	Electronic or Dynamic Book Used	Book Preference		
		B or C	Either	A
More Questions	B	8		
	C	6	1	1
Complex Question	B	4		4
	C	6		2
Reading a Chapter	B	2		6
	C	2	2	4

The questionnaire distributed after both sessions asked the additional questions:

1. With which question on the following page [one of the question lists in Tables 4-4 or 4-5] did you have the most trouble in finding information? Why? What would have made your task easier?
2. Were there any other questions which you found particularly difficult? Why?
3. What did you like the most about the computer system and/or paper textbook that you used today? What did you dislike the most? What other things did you like or dislike?

In response to these questions, students generally answered that they liked the computer-based subject index because it gave them faster access to subjects than the paper book index, but disliked the clipped subject phrases (this was because of limited space on the screen and because the headings and subject terms were designed for the paper book). They also liked the fact that they did not have to flip back and forth between the subject index and places in the dynamic book; this was cumbersome in the paper book. Random positioning to pages was faster in the electronic version than in the paper version, although flipping to neighboring pages could often be slower in the electronic version (Book B students mentioned this quite often). Pages in Book B tended to be longer than subsections in Book C, and hence took longer to retrieve and display; in addition, they usually required scrolling. This might be responsible for the increased shift to the paper-book preference by Book B students for the proposed chapter reading task. Several students also mentioned that they liked the highlighting of subject words in **boldface** because they

could skip over some information. Most students considered questions involving dates to be the most difficult; they also wished that they could have gone back to earlier questions. Students liked the mouse, but some disliked the screen because it appeared blurry after a period of time, and could not be read from far away; a larger typeface may have helped to correct this, but then even fewer subject headings and less text information could have been displayed on the same-sized screen.

Performance Comparisons

Data from the experiment were analyzed to see which groups of students answered the most questions correctly and/or most quickly. The size of the experiment, however, in addition to composition of the population and nature of the questions and task, will prevent us from drawing any very general conclusions. First, the question lists were tested for equivalence, with the possibility of using a subset rather than all questions in later analyses. Then, treatment groups were compared with respect to answer correctness. A similar analysis was used to look for differences in latencies between groups.

Question List Analysis

The raw data for these analyses is contained in Table D-1 in Appendix D. Equivalence of the two lists of twenty questions needed to be verified. By doing an analysis of variance on the correctness of all twenty questions in each list, and on the average of the questions, statistical differences between the two lists of questions could be detected. Each of 16 students used Book A with either question list 1 or 2, and either Book B or C with the other question list. This can be represented as a 2x3 unbalanced design (Winer, 1979), ignoring book and list orders. The linear model used here and in the later analyses can be represented as

$$X_{ijk} = \mu + \alpha_i + \beta_j + \alpha\beta_{ij} + \varepsilon_{ijk}$$

where

α_i relates to the i-th question list and
β_j relates to the j-th book or book order.

Table 5-2 represents the number of students for each book and list combination; the harmonic mean of 4.8 was used in the analysis for the number of observations per cell. Individual students received a score of 0.0, 0.5, or 1.0 for each question. Table 5-3 shows the total correct for the twenty questions by list and book. The totals for each question list and differences between list 1 and 2 are compiled in Table 5-4.

Table 5-2

Number of Students per Condition (Question Analysis)

Question List	Book		
	A	B	C
1	8	4	4
2	8	4	4

Table 5-3

Total Correct for 20 Questions by List and Book

List/ Book	Question																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1/A	7.0	6.5	4.5	1.5	5.0	3.0	5.0	0.0	7.5	7.0	5.5	6.0	5.5	2.0	5.5	5.5	3.5	6.0	3.0	3.0
1/B	4.0	4.0	2.5	0.0	4.0	2.0	3.5	0.0	3.5	4.0	3.0	3.0	2.0	0.0	2.5	2.0	1.0	4.0	1.0	0.0
1/C	3.0	3.0	3.0	0.0	1.0	2.5	2.5	0.0	3.5	4.0	2.5	3.0	2.0	2.0	1.5	3.0	1.5	1.0	0.5	1.0
2/A	7.0	6.5	5.0	6.0	4.0	7.0	5.0	6.0	6.0	8.0	6.5	6.0	3.0	3.5	4.0	5.0	2.0	5.0	3.0	3.0
2/B	3.5	3.0	4.0	2.0	2.0	3.0	3.0	3.0	3.0	4.0	3.5	3.5	1.0	4.0	1.5	2.5	2.0	4.0	2.0	2.0
2/C	3.0	4.0	4.0	1.0	3.0	2.5	2.5	4.0	3.5	3.0	3.0	3.5	1.5	1.5	1.5	3.5	2.0	2.0	2.0	3.0

Table 5-4

Total Correct for List 1 and List 2, and Difference Between List 1 and List 2

List	Question																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	14.0	13.5	10.0	1.5	10.0	7.5	11.0	0.0	14.5	15.0	11.0	12.0	9.5	4.0	9.5	10.5	6.0	11.0	4.5	4.0
2	13.5	13.5	13.0	9.0	9.0	12.5	10.5	13.0	12.5	15.0	13.0	13.0	5.5	9.0	7.0	11.0	6.0	11.0	7.0	8.0
1–2	0.5	0.0	-3.0	-7.5	1.0	-5.0	0.5	-13.0	2.0	0.0	-2.0	-1.0	4.0	-5.0	2.5	-0.5	0.0	0.0	-2.5	-4.0

Table 5-5 summarizes the analysis of variance, for the average of all 20 questions, and also for questions 4 and 8. These two questions are significantly different (indicated by "**") when a Bonferroni criterion of 0.05/20 for simultaneously testing all 20 questions is adopted. It should be noted that an analysis of variance may not be totally appropriate for this correctness data which is distributed binomially. As a screening method for the question lists, it is adequate; however, the data could be transformed if a more rigorous analysis were desired. Table 5-6 shows selected critical values for F for the degrees of freedom used in this analysis and in the analyses to follow. Values in these tables and in most other tables are rounded to two decimal places for ease of presentation.

In particular, a question list effect was sought. The analysis of the overall question average showed no difference that would cause us to reject the hypothesis that the questions lists are comparable. By inspection of the difference of the question list totals presented earlier, it is obvious that questions #4 and #8 have the largest discrepancies; they also have the largest F values. For question 4 in list 1, the total correct was 1.5, versus 9.0 for the matched question in list 2. For question 8, the difference is even larger: no one got the question right in question list 1, and 13.0 was the total score for list 2. By eliminating these two questions, the total correct for question list 1 becomes 177.5, versus 190.0 for question list 2. Because this analysis was used only

to verify that the two lists were comparable in difficulty, it ignored the experimental factors of list and book order, which will instead be considered in the analyses to follow.

Table 5-5
Analysis of Variance Tables for Question Lists

Source	df	SS	MS	F
Averaged Over All Questions				
Mean	1	14.75	14.75	454.3
Book	2	1.59	0.80	24.52
List	1	0.09	0.09	2.91
BxL	2	0.00	0.00	0.04
Error	26	0.84	0.03	
Question 4				
Mean	1	4.25	4.25	26.21
Book	2	2.55	1.28	7.86
List	1	1.95	1.95	12.04**
BxL	2	0.68	0.34	2.09
Error	26	4.22	0.16	
Question 8				
Mean	1	6.52	6.52	75.34
Book	2	0.49	0.24	2.81
List	1	5.87	5.87	67.81**
BxL	2	0.49	0.24	2.81
Error	26	2.25	0.09	

Table 5-6
Selected Critical Values of F

$1-\alpha$	Degrees of Freedom			
	Denominator	Numerator		
		1	2	3
.75	8	1.54		1.67
.90		3.46		2.92
.95		5.32		4.07
.99		11.3		7.59
.995		14.7		9.6
.75	12	1.46		1.56
.90		3.18		2.61
.95		4.75		3.49
.99		9.33		5.95
.995		11.8		7.23
.75	26	1.38	1.46	
.90		2.91	2.52	
.95		4.23	3.34	
.99		7.72	5.53	
.995		9.4		

Group Difference Analysis for Correctness

In the analyses that follow, an 18-question subset of the 20 questions (omitting questions 4 and 8) is used. The design is a 2x4 balanced analysis of variance. The rows represent the question list (1 or 2) that a student received for the control treatment, Book A. The columns represent the order of the two books that a student used, either AB, BA, AC, or CA. The values are difference scores, of [experimental (B or C) - control (A)] for each student (Brogan and Kutner, 1980). Table 5-7 shows that there were two students for each combination in the design.

In the analysis, groups were compared on the basis of the differences for correctness scores on the two occasions. As can be seen from Table 5-8, none of the differences is statistically significant. Of course, an analysis with a larger sample of questions and larger number of students might detect such differences as significant.

Table 5-7

Experimental Design and Number of Students per Cell

Control Question List	Book Order			
	AB	BA	AC	CA
1	2	2	2	2
2	2	2	2	2

Table 5-8

Correctness Difference Means and Analysis of Variance

Correctness Difference Means

List	Book Order				List Mean
	AB	BA	AC	CA	
1	-0.50	2.50	1.50	1.25	1.19
2	2.25	-1.00	0.00	-2.75	-0.38
Book Order Mean	0.88	0.75	0.75	-0.75	0.41
Book B Mean	0.81				
Book C Mean			0.00		

Analysis of Variance

Source	df	SS	MS	F
BC vs. A	1	2.64	2.64	0.48
Book Order	3	7.17	2.39	0.43
List	1	9.77	9.77	1.76
BO x L	3	28.30	9.43	1.70
Error	8	44.38	5.55	

Group Difference Analysis for Latencies

In looking at latencies, i.e., the length of time from start of question to end of answer, two problems come to mind. The first is that the data themselves are probably skewed with unequal variances, with more short values than long values. Taking a (square root or log) transform of

the data tends to eliminate this skew. Figure D-1 depicts the latency data after the square root transform. The latencies for all questions in both lists answered correctly by four students are displayed in a "box and whiskers" format (Tukey, 1977) for each treatment group, in order to give a sense of the distribution of the values. The central horizontal line represents the median value, and the two horizontal box boundaries mark the quartile values, with the box length being the "spread." The vertical line defines the minimum and maximum values. The other horizontal lines ("whiskers") define the "inner fence" values, which correspond to a distance of "1.5 times the spread" from the quartile values but not outside the minimum or maximum values. Figure D-2 displays the same data before the square root transformation occurred.

The other problem with latencies is that they fall into two categories, those for correct answers and those for incorrect answers, especially because questions can be skipped or answered incorrectly in less time than it takes to enter a correct answer. Although students were encouraged to not give up too soon, there were quite a few instances of questions skipped after only a few minutes. There were also a few students who had unanswered questions remaining after the two-hour limit. One solution is to consider latencies only for correct (1.0) or partially correct (0.5) answers -- a common procedure in psychological experiments for reaction times. This means taking a further subset of the data for analysis: out of 576 possible answers, there are 427 responses that are at least partially correct. Of course, in looking at differences of latencies, this number may be reduced even further in cases in which a latency for a correct answer must be discarded because the answer to the paired question is incorrect. (More latencies could be included if the correctness criterion included finding the right place in the book. However, these data are available only for Books B and C, and would require more detailed judging.) Another solution, the correction of incorrect latencies, will be described later. Table 5-9 summarizes the latency difference analysis for 18 questions, for correct or partially correct responses.

Table 5-9

Latency Difference Means and Analysis of Variance

Latency Difference Means

List	Book Order				List Mean
	AB	BA	AC	CA	
1	-1.15	-0.26	-0.95	0.62	-0.44
2	-2.33	0.42	-3.60	0.46	-1.26
Book Order Mean	-1.74	0.08	-2.27	0.54	-0.85
Book B Mean	-0.83				
Book C Mean			-0.87		

Analysis of Variance

Source	df	SS	MS	F
BC vs. A	1	1.28	1.28	6.29*
Book Order	3	22.47	7.49	4.10
List	1	2.70	2.70	1.48
BO x L	3	6.16	2.05	1.12
Error	8	14.62	1.83	

Because the List effect and the Book Order/List interaction are not significant, these were pooled into the Error component. Because the Book effect is significant ("*" indicates significance, $p < 0.05$), it was split into its three components: AB vs. BA, AC vs. CA, and B vs. C. Table 5-10 displays the recalculated analysis of variance table.

Table 5-10

Latency Difference Analysis of Variance with Error Components Recombined

Source	df	SS	MS	F
BC vs. A	1	1.28	1.28	5.87*
B vs. C	1	0.01	0.01	0.00
AB vs. BA	1	6.64	6.64	3.39+
AC vs. CA	1	15.83	15.83	8.09*
Error	12	23.48	1.96	

The large BC vs. A (grand mean) effect indicates that the overall latency difference is significantly different from 0 ($p < 0.05$). Because the grand mean is negative, and because the difference is always formed by subtracting the control (A) latency from the experimental (B or C) latency, this implies that, in general, students using the paper book took longer to answer questions correctly than those using either B or C. Although this difference is statistically significant, it is not particularly large, as can be seen by examining Figure D-2 (the median and quartile values are close for the different book orders, though the minimum and maximum values do differ).

The Book Order effect implies that AB, BA, AC, and CA are not all the same. By partitioning the variance further, we can see that there is a difference between AC and CA ($p < 0.05$), and a smaller difference between AB and BA ($p < 0.1$), but no difference between B and C. Again by looking at the means, we can see that those using books in the order AB were faster than those in the order BA; similarly, AC students were faster than CA students. It appears that order does make a difference, that students who received the experimental treatment second (AB and AC) were faster at finding correct answers than those who had the experimental treatment first (BA and CA). It may be that having the control treatment first gave students some practice with the mouse and in making selections; this practice may have been more useful in using the electronic or dynamic book second, than the other way around.

Another way latencies can be analyzed is to substitute a latency correction factor for incorrect responses. Because students were told to skip a question after 8 or 10 minutes if they were having little success, one method would be to use 8 minutes or the actual latency, whichever is greater, for the incorrect response as a way of penalizing fast but incorrect answers. Figure D-3 shows a distribution for latencies corrected in this way. Not surprisingly, there is a certain amount of clustering introduced around 8 minutes. The results of analyzing these corrected latencies are similar to the results of the analysis of correct-only latencies, except the former's significance level is greater.

Given the fact that students using the electronic or dynamic book did not have much practice with it before using it in the experiment, we might regard the first ten questions as training

questions in the use of this new type of book. One might expect then that the difference between computer and paper versions would be even greater on the second ten questions as students mastered the use of the electronic or dynamic book. An analysis of the subset of questions 11-20 showed no treatment group differences with respect to answer correctness or latencies by either method. Students may have made more mistakes, skipped more questions, or gotten tired as the two-hour limit approached. Given that question pairs were ordered randomly, we would not expect that the second half of a question list would necessarily contain further examples of the same kind of questions encountered in the first half; there were, for example, two comparison questions and one analogy question in the second half and none in the first half. In other words, learning some of the mechanics of a dynamic book may not necessarily help the user to answer a different kind of question more quickly. Figure D-4 displays latency difference means presented over time (i.e., for questions 1 through 20, omitting 4, 8, and 14 -- the mean for question 14 was based on only one pair of values) for both Books B and C, averaged over from two to eight students for each question. Book A is represented by the zero baseline. A positive difference value for B is favorable to Book A; a negative difference favors Book B. A more careful tailoring of question lists and training sequences would be necessary to identify such learning trends.

Question Analysis

Even if there had been no differences between the three books with respect to overall student use, there still might have been differences with respect to individual questions or questions of a particular type. One might like to ask, "Was Book B faster than Book A for question 1?" or "Were Books B and C faster than Book A on comparison questions?" and answer these by using the same kind of analysis used earlier to test for differences between group means, this time basing the analysis on individual questions or subsets of questions. However, the overall sample size is not large enough to be partitioned for such analyses. As noted earlier, latencies for correct or partially correct answers were used; using differences requires both answers to the questions in the same pair to have been at least partially correct.

For exploratory purposes, we might group the data for each question-pair difference by electronic or dynamic book used, noting, for example, that students using Book C answered 80 seconds faster for questions in pair 1 than when using Book A; students using Book B were 23 seconds slower when using Book A. From these groupings and results, it might be preferable to use Book C for answering question 1, next preferable to use Book A, and finally to use Book B -- this order is represented as CAB. Figure D-4 displayed the latency difference means for Books B and C with respect to Book A for each question. Because each mean shown is based on from 2 to 8 paired observations, the error of measurement may be large. Table 5-11 summarizes these rank-ordered relationships from the graph, ignoring the issue of magnitude or reliability of the difference. Questions 4 and 20 have means for only one of the books, with the other one undefined. Question 8 was omitted because it had no observations, and question 14 because it had only a single observation. Several values differed from each other by as few as 8 seconds. Thus, questions 3, 6, 7, and 19 lie near the borderline of other classifications.

Table 5-11
Preferred Possible Book Order With Respect to Latency for Specific Questions

Book Order	Question Numbers
ABC	3, 4, 7, 15
ACB	19
BAC	10, 12
BCA	13
CAB	1, 2, 5, 6, 20
CBA	9, 11, 16, 17, 18

If one could trust such a categorization, then common attributes of questions in the same category might indicate advantages or disadvantages of one book over another. For example, the questions in category CBA had relatively large mean differences compared to the other categories and would seem to favor Book C, then B, and finally A. Question 9 is a multi-part question requiring access to several parts of the book. Question 11, concerning early farming or non-farming in the Americas, typically requires several accesses to the subject index also to find the right description. Question 16 asks several related questions about geography and early civilization in China and India. Question-pair 17 compares four legal or religious codes in one question and educational opportunities for women in four cultures in the other question. Question 18 involves examining the names of several dynasties or a list of events in order to determine the origins of the names "China" and "England."

One hypothesis might be that Book C works best for comparison questions or questions involving many accesses to the text or subject index. However, question 13 is also a comparison question and favors Book B over Book C, although both are better than Book A. Either the data is incomplete or there is something not yet considered about how the particular comparison questions interact with the book. For date-oriented questions, such as 4, 7 and 19, Book A appears to be a slight favorite although Book B is second-best for question 7 and Book C is second-best for question 19. As noted earlier, the data for these questions is even less conclusive. If Book A is indeed superior, it may be that physically flipping pages of Book A or examining long lists of sub-subject terms in the paper version of the subject index gave faster access on date-oriented questions.

Redesigning the questions to be more nearly identical, both within pairs and between analogous pairs, within a well-defined question space, and using a larger sample would both be required. More fundamental, however, is the issue of whether such measurements, i.e., overall time to answer a question, are of educational interest themselves or of any help in describing the search process.

Chapter 6. Summary and the Future

Summary

In our journey across the ocean of information, we have visited many places. This dissertation has attempted to sketch a preliminary map, to present the results of one exploration, and to suggest some promising directions for future expeditions.

General Problem

Information-seeking, search skills are central to many learning tasks, from finding simple facts and comparing similar events in an encyclopedia, to pursuing complex research questions. Search is part of the larger educational process of inquiry: generating questions and collecting and evaluating information in support of an answer. The process of search, as in navigation, involves charting and following a course to reach a goal. Yet, categorizations of the tactics for an overall search strategy, how to plan a strategy, and how the tactics interact with a question and with the structure and content of information have not been clearly described.

Because traditional books inadequately represent the complexity of information and do not provide flexible access, they make searching and sifting difficult. This problem is compounded by the ever-increasing amount of information. Computer databases and electronic versions of books and libraries have been suggested as solutions but have not been evaluated thoroughly, especially in educational settings. A dynamic book, a more advanced electronic book consisting of a powerful user interface to a complex computer database of information, could become a new information source and a new form for old information, a book that could evolve to match the complexity of multidimensional information and to help us actively in searching. This help could take the form both of augmenting search techniques, and of creating information about the search itself, new information that can be queried and managed. As inevitable and potentially powerful as such books might be, little is known about their design and evaluation. People using preliminary versions of dynamic books provide us with opportunities to observe the human search process and to influence the design of these books.

Questions

This dissertation explored several questions:

How do students look for information?

How do the designs of dynamic books interact with the search process?

How much training is necessary to use a dynamic book?

What tactics do students use and how can search strategies be compared for different versions of a book?

How do the books differ with respect to student performance and preference?

Background

Studies related to asking questions, searching for information, and accessing structured information are plentiful in the education, psychology, library science, and computer science literature. One paper about search strategies, and two empirical studies of databases were considered the most relevant to the experiment discussed in this dissertation:

Bates (1979) described search strategies and identified search tactics for professional searchers;

Joyce and Joyce (1970) created an off-line database of social studies materials and observed elementary students who asked questions through an adult intermediary;

Rouse and Rouse (1980) designed and compared several versions of an on-line manual with a paper manual for the task of following procedures.

This dissertation presented research visions of dynamic books, database concepts, and distinguished document-oriented from record-oriented database systems. User-interface features that might aid in the search for and management of information (such as highlighting, subject pattern matching, and marking) were illustrated with examples from the Findit system (Weyer and Kay, 1976), implemented within the Smalltalk programming environment at Xerox Palo Alto Research Center (PARC).

Methodology

The textbook, *Our Common Heritage: A World History*, was obtained in its digital form. Three versions of the textbook, pictures excluded, were used in the experiment:

A Paper Book. Book A consisted of two parts: an off-line paper printout of the textbook, loosely bound (different from the published, hardcover textbook: for example, it lacked pictures), used for finding information; and a simple user interface used for presenting questions and collecting and storing answers on the computer. (See Figure 4-1 for a picture of the 3-part "window" displayed on the computer screen, and Figure 4-2 for sample portions of the subject index and main text that appeared on paper.) The search task in Figures 4-1, 4-4 and 3-7 was to "List four things that the concept of culture includes."

An Electronic Book. Book B (Figure 4-4) implemented the same computer interface as Book A for questions and answers, but provided access to an electronic, on-line book on the remainder of the screen through a more complex window, or "information browser." Access to the text, like Book A, was done by using page numbers. It did provide several dynamic features, however, in common with Book C: words that occurred in the current subject phrase were "highlighted" in the main text (as was **culture**, for example, in Figures 4-4 and 3-7); and, as with Book C, the user could manage lists of subject phrases and text references by checking off, adding, and saving items.

A Dynamic Book. Book C (Figure 3-7) provided access to the on-line text through an expanded outline of chapter, section, and sub-section headings (a 3-level hierarchy of titled locations in the text, rather than the page numbers used in Book B). In addition to subject word highlighting and the management of subject phrase and title references, Book C added dynamic features for matching patterns in the subject index (non-alphabetical search) and accessing an inverted subject index (additional subject cross references).

Off-line student guides (Appendixes A, B, and C in the dissertation) were created and used to introduce students to the different interfaces. Two equivalent lists of twenty history questions each were constructed (an earlier pilot study suggested changes in the length and composition of these lists). In an experiment, 16 eighth-grade students, in eight groups of two students, looked for answers to these history questions. Each student used Book A, the "paper" book, in a two-hour session on one day; this comprised the control treatment. On a different day, each student used either Book B or C, the "electronic" or "dynamic" books respectively, to find and enter answers for an equivalent list of 20 questions; this comprised the experimental treatment. In the 2x4 balanced design (Table 4-2), each group of two students received two lists of questions in one of two orders (1-2 or 2-1) and used two books in one of four orders (AB, BA, AC, or CA), on two consecutive days.

Measurements

For protocol analysis, the actions of Book B and C students were recorded to give a detailed description of their use of the browsers. The underlying computer system for each book automatically collected the answers to questions and the latency for each answer, which permitted some performance comparisons. Finally, students answered questionnaires to indicate book preference and problems.

Results

Students learned to use the basic features of the books with minimal training, but clearly needed more instruction and practice in the more advanced features. Protocol data, collected by Books B and C, were used to identify successes and problems related to tactics of accessing lists of items, accessing the book through its order, following cross references, and saving and returning to items. Different types of questions (for example, comparison questions or questions containing dates) made special search demands. Protocol examples distinguished between the errors due to inadequate knowledge about and use of tactics, errors due to inadequate training in operation of the interface, errors due to the interface layout and implementation, and differences due to the search behavior encouraged by the electronic and dynamic books.

As an example of a tactical error, a student might focus too long on subject terms beginning with "French" rather than beginning to look for entries under "government" (a different semantic category) or under "France" (a lexically-related term). Another example is a student's continued sequential reading of pages within an inappropriate time period. Browser layout caused errors in

making selections and in ignoring information that was only partially displayed (page scrolling and truncated terms). "Following a cross reference" was implemented as multi-step operation in the browsers. Because of this complexity and their inadequate training, students followed cross references infrequently or incompletely.

The differences in search strategy that were attributed to the design of Books B and C lay in the areas of accessing by page number vs. heading access, using subject-patttern matching, and using cross references. Questions with dates often forced students to do more exploration in the page or heading structure of the book. Although the named access of Book C should have given more direct access than the page numbers of Book B, the results are inconclusive. Pattern matching of subject terms gave Book C students an additional tactic, and some students used it successfully. However, other students also used it sometimes, apparently only because it was novel and available, and not because it was more appropriate or effective than another tactic. Finally, the additional cross references of Book C, though they provided a potential source of new terms for several difficult questions, were not exploited by students.

From the questionnaires, students preferred Books B and C for the question-answering task and to a lesser extent, for the related, hypothetical tasks. They also pointed out the design features that they liked or disliked in the different user interfaces. Analysis of group performance data revealed a slight speed advantage for Books B and C over Book A. A result of "Computers are faster or better than paper books" neither is generalizable from the small, exploratory experiment presented here, nor appears a particularly fruitful approach for future evaluations of dynamic book designs or for understanding the search process.

Conclusions

This experiment demonstrated the feasibility and desirability of using dynamic books for the particular educational task of seeking information to answer questions. A classification of student search behavior was presented, and illustrated with examples of successes and problems. Improvements in training to generate and choose tactics, in learning to operate user interfaces, and in designing books were suggested.

The technology surrounding dynamic books will continue to improve, to become more available, and to outdistance our ability to use it effectively. We must better understand how people describe questions or queries and how this description guides a search strategy in interaction with an information source. Experience with dynamic books in other learning situations will suggest other opportunities and problems, such as the problem of how a dynamic book might, for example, help a student to ask better questions, to find, interrelate or remember information, or to synthesize better answers. Such research should help both in designing qualitatively better dynamic books and in better training searchers and learners to use them.

The Future

As seen in Chapters 2 and 3, the work on dynamic books intersects many areas of endeavor such as the work in document and database systems in computer science, research on books and publishing, categories in psychology, studies of indexing in library science, uses of information in education, and visions of dreamers. The goal is to improve the representation and usefulness of information and our understanding of how people access it. The current research in dynamic books can be extended in one or more of these directions, in short hops along a predictable coastline or in larger exploratory voyages. Some of the possible minor and major future advances in the evolution of dynamic books are discussed next.

The Experiment Revisited

If a similar experiment were to occur in the near future, what incremental changes might be made? Given the observations about user errors from Chapter 5 and the availability of larger displays, the browsers could be redesigned to display more relevant and complete information. A more ambitious goal would be to include a set of capabilities that could enable the user to reconfigure or build a browser to match his search tactics and style. The same history book content could be expanded to include pictures and animated maps, or possibly translated into a network of related events with associated text descriptions. Access to the book could be augmented by free-text search, timelines, geographical and political maps, an improved subject index or concept network, more consistent headings, and other query styles. Students should receive more training in the use of the browsers, in the context of a curriculum for strategic approaches to questions. In this way, students could form an explicit model of tactics and their realization through the browser. If the system possessed such a model, it could offer tutorial aid. A more modest aim would be to provide an on-line curriculum and browser manual.

Of course, the design of the book, browser, and search model assume certain kinds of questions and tasks. More difficult and different kinds of questions could be generated from a better question classification. In addition to locating information, students could be asked to remember intended or incidental information, to write complex essays, or to teach someone else about the area. Instead of using the book as an encyclopedia, how could it be used as a dynamic textbook by the teacher, by a group of students, or an individual student? The emphasis could be on creating or writing rather than reading a dynamic book. The history book itself could be replaced by a physics book, computer manual, or database of scientific observations. Another learning environment would be for the book to be part of a dynamic library of interconnected books. Finally, the system could be used by people of other backgrounds and ages. Clearly, there are many possible choices of direction within this large design space. The problem again is one of navigation -- how best to exploit experience from related areas and to apply intuition in the exploration of a new domain. The following areas offer other perspectives and opportunities.

Document and Database Systems

Information systems will occupy increasingly diverse niches in our environment: our homes, schools, offices, factories, vehicles and bodies. Different information content and needs will drive the development of special purpose applications; new general systems will arise to integrate these seemingly diverse functions. It is taken as a given that computer systems will become cheaper, smaller, faster, more interconnected, and more available and useful to more people. The issues that will be explored below concern how these systems can be unified and simplified, especially from the perspective of the eventual user.

Currently, information systems are implemented with different network protocols and information formats and communicate with their users via diverse query and manipulation languages. The differences are not undesirable unless the user would prefer not to cope with the conflicting conventions of numerous systems. Ideally, the user should deal with a single interface that helps its user formulate queries for information and manipulations of information. Such an interface would then translate these requests for all systems.

For querying, the language could combine features of graphical templates, hierarchical menus, and expressions in a programming language or a restricted form of natural language, and permit fluid movement between the concrete space of examples and more abstract descriptions; for manipulation, the language could use algorithmic approaches from programming languages, or fixed operations as in statistical or report-generating programs. As query languages contain more powerful methods for manipulating information, and as programming languages allow more general forms of description, these currently separate evolutionary paths should converge.

There is also a commonality of function among documents, data structures, records, databases, semantic networks, and knowledge representation languages, each with a slightly different context for use. Such objects must be able to contain not only textual and numerical information, but also animated pictures and maps, sound, and active references to other objects. Free-text search and automatic indexing should be ever-present options for dealing with information when viewed in an unstructured way.

For example, a history textbook can be regarded as a collection of characters, a collection of pages, or a collection of facts, events, and beliefs related together by a dynamic model of the world and society. In some sense, history could be viewed as a simulation. Questions such as "what might have happened in the Civil War if a particular battle had been won instead by the Confederacy, or what the result of a bad winter or outbreak of disease might have been" are in the realm of speculation rather than within the capabilities of current simulation systems. However, given sufficient past data and accurate models, it is not inconceivable that someone could explore the implications of his assumptions by asking the system to extrapolate trends, for example, in charting the economic indicators of a country or in predicting the effect of industrialization on energy use and pollution. This kind of "what if" question is also a request

for information, although it may involve a computation or simulation rather than a retrieval of known information from the system.

A historical event might be represented as an explicit structure that indicates the geographical area, time, and main people involved in the event, in addition to a textual description. In this way, a document-oriented representation could be shifted in the direction of templates or semantic networks. At a higher level, events can be presented and interconnected to emphasize key points about agriculture, government, religion, society, science and culture. These themes can be seen to be part of a larger structure, contributing to such questions as: what are the important questions to ask about a civilization? The paper analog of this structure is the chapter of a book. However, the structure is often not made explicit between chapters by parallel presentation and headings.

Thus, an ambitious generalist might create a language for description and manipulation that could subsume the functionality of programming languages, database systems, operating systems, editors for text and pictures, simulation systems, and artificial intelligence and knowledge representation languages. (Smalltalk is one small step in this direction.)

Books and Publishing

Publishers and authors can continue to produce books in the present, paper-oriented way, using computer systems for editing, proofreading, laying out pages, and generating indexes. But these books could also be made available in other forms, such as on videodisc or in a document-oriented computer system. As paper becomes more expensive and as dynamic books reveal their advantages for art, training, and reference, the latter could begin to supplant paper books and magazines. Teletext and videotext systems that survive the test of the marketplace will offer information services that compete with off-line guides such as the telephone yellow pages, department store catalogs, and newspapers. This introduces some practical problems that need to be solved: how does one write for this non-linear medium? how are authors, publishers and libraries to be encouraged to create, package, and store these new books? Nelson (1981) addressed some of these issues. A new generation of books on writing style should appear -- with the books themselves dynamic and offering examples and help for the construction of other dynamic books.

The popular media poke fun at the notion that books might be replaced by computer technology, and make it sound uncomfortable and unromantic. Russell Baker (1980) commented in a newspaper column about computerizing a college library: "You can't just haul a computer out on the campus and plunk it down under a budding elm and lie there with the thing on your chest while watching the birds at work, can you?" An editorial comment in a recent *San Francisco Chronicle* (The Future of the Book, 1981) romanticized about the aura of books: "There is a world of difference between peering at the impermanent flicker of a video tube and the satisfaction of poring over the pages of a musty tome."

One does not have to be a Luddite to resist replacing books with current, creaky computer technology. However, as systems improve, how will we decide whether reading a novel, textbook, or newspaper printed on paper will continue to be more relaxing, romantic, or efficient than reading a dynamic book published on silicon? -- one is more traditional but they are both "natural." Perhaps for those traditionalists, mustiness and a leather binding could be made available as options on the dynamic book, in addition to the ever-present option of printing your own copy on paper.

Search: Categories, Indexes, Structure and Questions

A fundamental question is how to represent a body of knowledge so that a person can find, understand and learn it. Tactics for search interact with the structures of the document space, which includes subject indexes and maps. As new kinds of maps evolve, so, too, our repertoire of tactics will grow. However, it may be that a subset of these tactics are basic, and that others are optimizations or good for use in special circumstances. A model for search needs to be developed that can specify when such tactics can be applied in a given situation. Because all tactics may not take the same amount of time or be of the same effectiveness, a model must assign priorities. A problem for education is to collect salient examples that impart search skills for transfer to similar situations. Because searching is only a means to an end, it is important to understand how search structures aid or interfere with more complex educational goals, for example, how the scope of a question interacts with how one focuses on information that is either relevant and important or merely peripheral and to be absorbed incidentally, if at all. The earlier studies cited about learning and recalling from structured text could be expanded to distinguish further what structures under what conditions are appropriate for different learning tasks, including search.

Dynamic books could be accessed in many ways: through concept-oriented structures like topic outlines and the *Propaedia*, subject indexes and card catalogs, dynamic maps, timelines, references from other books, and the text itself. Such indexes could be fitted to the needs and background of an individual searcher, for example, by substituting proper technical terms for commonly used words or vice versa, adding or hiding levels of detail, and providing related items in a more powerful semantic structure. If the document could adjust itself to the individual, to what degree would the individual need to be trained in order to use the document or index? What criteria will be used to classify the background and ability of an individual and the complexity of an index or knowledge structure?

The content and structure of a body of knowledge can be reflected also in the collection of questions that can be asked about it. Current indexes are the result of anticipating a particular collection of questions; answering unanticipated questions is much more difficult. Semantic categories (examples were given in Chapter 2) can be used to structure the facts, beliefs, inferred information and relationships among these in a complex situation. The geographic and trade relationships between France and England; the conceptual structure of religion, its abstract attributes, instances (Buddhism, Judaism, primitive rituals), developmental and comparative views

of religion, and influences on other areas of life such as government or art are examples. A taxonomy of possible questions about religion might mirror the structure of the information itself, but would have to include also all of the unanticipated questions and not-yet-made inferences and hypotheses about this subject.

In understanding search, we should also include the form and content of possible questions. Some general question types might be fact-retrieval, comparison, causal connection, or opinion formation. These requirements relate to the amount of information found, the detail with which it is examined, and the form of the answer. Such a question-oriented approach might make it possible to associate different kinds of strategies for locating and reading information with different kinds of questions, even in unfamiliar subject areas.

Education

There are many opportunities in education for using and improving dynamic books. Two basic educational questions arise when considering the careful application of this technology. First (to paraphrase Samuel Johnson from the Introduction), how much emphasis should be put on knowing where we can find information about a subject, and how much on knowing the subject ourselves? And second, how and when should a system offer help? What value is there in allowing the student to struggle or discover things for himself?

As search is emphasized, the larger issues of how to ask the right questions and what to do with the information must also be addressed. Once the barriers of accessing information are overcome, we should ask also, "What part of this information is important, correct, relevant, or interesting?"

As dynamic books are adopted, many tasks and problems will arise. Students will need to learn how to use such books to describe and search for information, and to follow paths through its structure. Ideally, the book itself will offer training and help to the student who is using it (assuming a model of the search goal and the user's background and progress). Using a dynamic book effectively will require learning also how to plan a search strategy and how to apply search tactics. Accessing an interconnected dynamic library of such books may require other skills. If people can answer questions more easily, they may ask more questions. Such an educational context might motivate curiosity and foster inquiry skills.

Dynamic books offer an environment in which to experiment with the presentation of information. Previous efforts in textbook design were concerned with issues such as indentation and line spacing. These and other aspects such as color, layout of pictures and diagrams, and inclusion of dynamic objects such as animated maps, simulations, and games, should be easy to vary in a dynamic book. New forms of presentation specific to a subject area are possible, such as animating time-rate-distance algebra word problems (Gould and Finzer, 1981), experimenting with the laws of motion in physics, or changing political boundaries on history maps.

A dynamic book does more than just replace static pictures with animated ones while the linear, fixed prose remains. A simple example is to provide increasingly more detail and related items on demand. Another view is that the text is just one exposition or explanation of an underlying phenomenon -- the explanation could change not only because the reader shifted viewpoints but also because the model of events or relationships was updated (for example, new data might make Einstein's theories obsolete) or the system noticed the reader having difficulty and offered tutorial aid for the subject at hand and suggested related topics and activities to pursue.

Dynamic books could provide a framework for simulating and expanding the power of many current manifestations of educational information: programmed textbooks and CAI for training and testing; reference sources such as encyclopedias and libraries; collections of curriculum materials and learning activities; personalized textbooks that give students different views of a subject; notebooks for organizing a student's observations, writing reports, and saving the annotations in textbook margins; a communication medium for orchestrating and augmenting class discussions; and other traditional uses for books, such as serving as doorstops.

A massive educational application was suggested by Servan-Schreiber (1981). Because the gap between developed and less developed countries has been widening, not only in terms of standard of living and industrial resources, but also in terms of access to information, he proposed that Third World nations be given the benefits of advanced information technology as soon as possible to help eliminate these inequalities. By "leapfrogging" the nations over the Industrial Age, directly into the "Information Age," helping their peoples to become not only literate but also fluent in this new technology, these countries could develop their human resources before their oil and mineral resources are depleted. Whether networks of computer-based information systems can in some way avert a world catastrophe is an exciting question for exploration.

Dreams

This dissertation represents the realization and description of one particular dream about uses of dynamic books. Inevitably, other dreams about dynamic books will begin to materialize, although they may appear in piecemeal fashion and unexpected form. As dynamic books begin to evolve, so, too, will our formulations of what is possible and desirable. In whatever guise or form, dynamic books should give mastery to individuals over an information environment that otherwise appears intimidating and complex.

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Appendix A

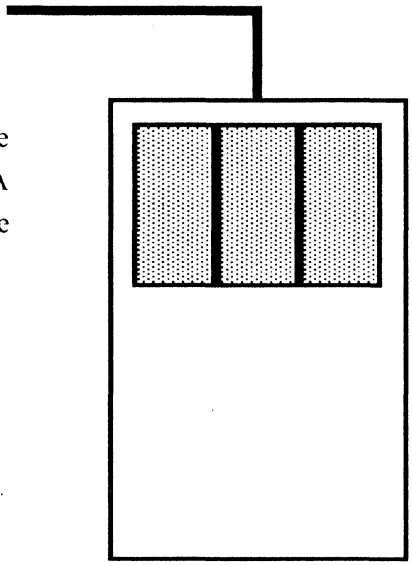
Student Guide for Book A (the "paper" book)

General Introduction

The Findit system will present you with questions. You will then use a textbook (either a paper version or an electronic or dynamic version) to look for some information, and type in your answer.

Mouse

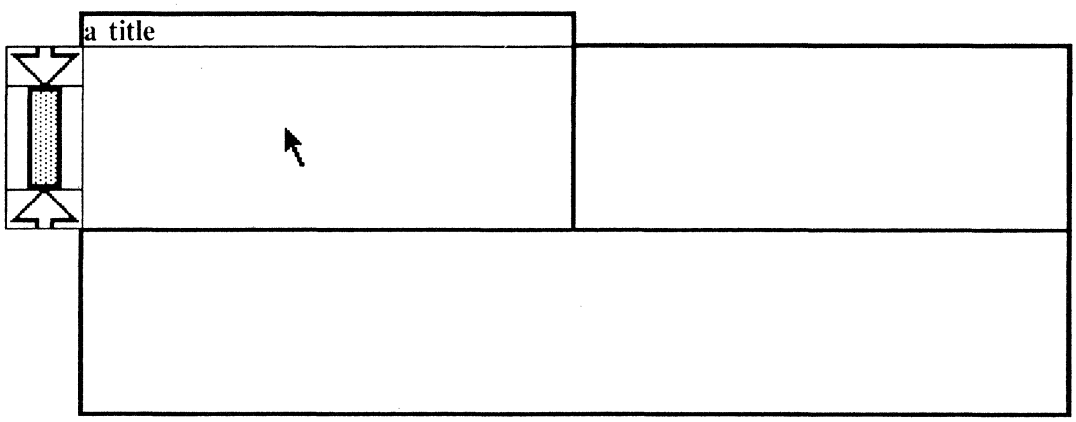
When you move the *mouse* (a pointing device) firmly across the table, an arrow (called the *cursor*) will move on the screen. A picture of the mouse appears on the right, and a picture of the cursor appears below.



Windows and Panes

The large segmented area on the screen in front of you is called a *window*. It contains many small areas called *panes*. The pane that contains the cursor is called the *active* pane. A *scrollbar* will appear on the left side of the active pane, and usually a *title* will appear above it. These will disappear when you move the cursor to another pane.

In the Figure below, the window contains three panes. The cursor is in the upper left pane. A scrollbar is on the left of this active pane and its title appears above it.



An Experimental Window

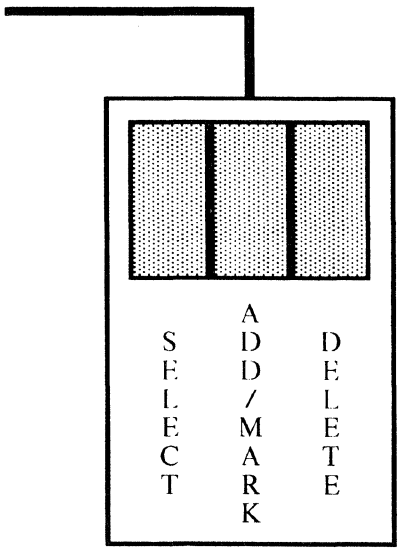
The Figure below shows a window with three panes (and their titles) that you will use in the experiment in conjunction with the paper textbook. The same three panes will also appear at the top of the window used for the electronic or dynamic textbook. Note that all of the titles are visible in the Figure to help identify the different panes, but on the screen, only the title of the active pane will be visible.

The pane labeled "Commands" is used to ask the system for another question and to inform it that you finished your answer. It also displays the elapsed times for the current question and for all questions. The Question pane displays the current question. The Answer pane will contain your answer

Commands	Question
start first question end this answer 0:00 (this question) 0:00 (all questions)	
Answer	

Mouse buttons

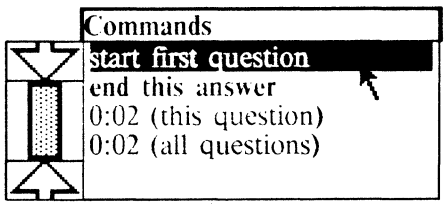
The mouse has three buttons, labeled SELECT, ADD/MARK, and DELETE, respectively from left to right. The SELECT button is the one you will use the most; the other two may be useful with the electronic or dynamic textbook and will be described later. Below is a picture of the mouse with the buttons labeled.



Selecting an item

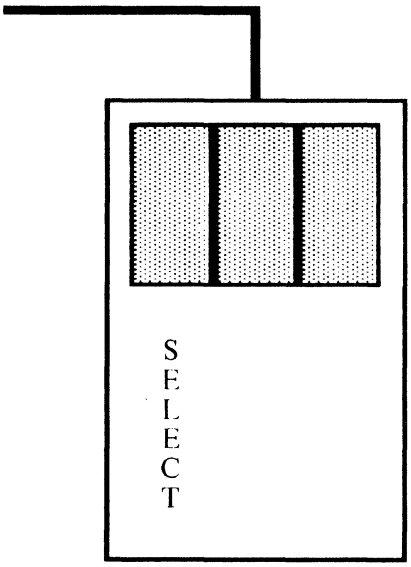
By moving the mouse, you can make the cursor point at whatever item you like. To select something, hold the mouse firmly with the cursor pointing at the desired item, press down the SELECT button and then release it.

When you select something, the line containing the current selection *complements* -- the background changes to black and the text changes to white to let you know which item you selected. When the cursor arrow contains a "star" in it (see picture below), the system is busy satisfying your selection and will not respond to you until it has completed its work. When the cursor changes back to just an arrow with no star, you can then make further selections. Only one item may be selected at a time. Your selection may cause changes in other nearby panes.



Complemented selection

Cursor with a star in it

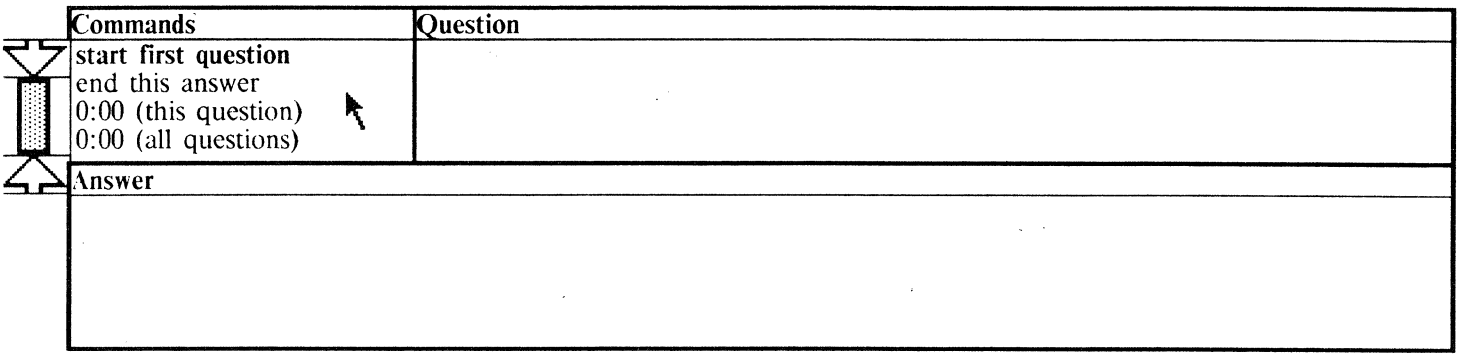


SELECT button on mouse

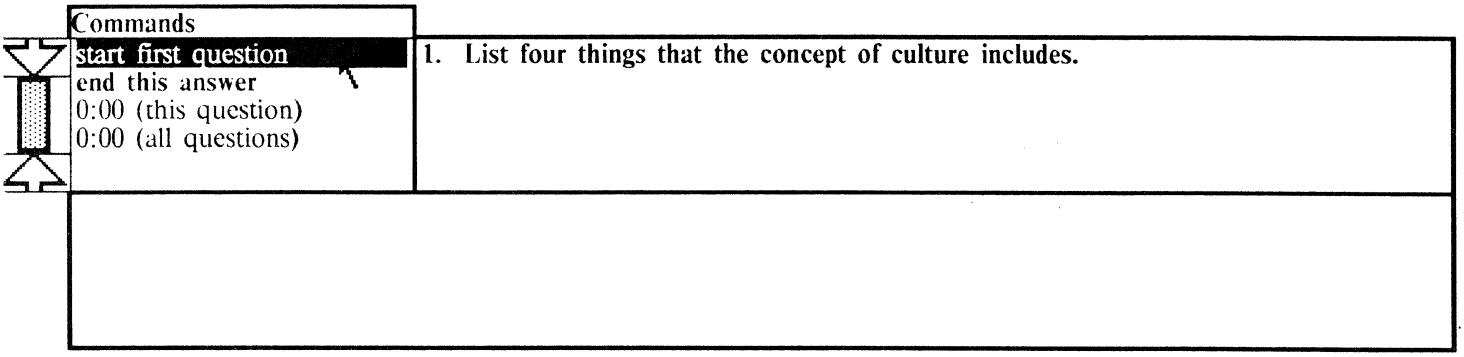
Selecting a Question, Entering an Answer

For example, the Figures on the page below show the sequence of selecting a question and entering an answer.

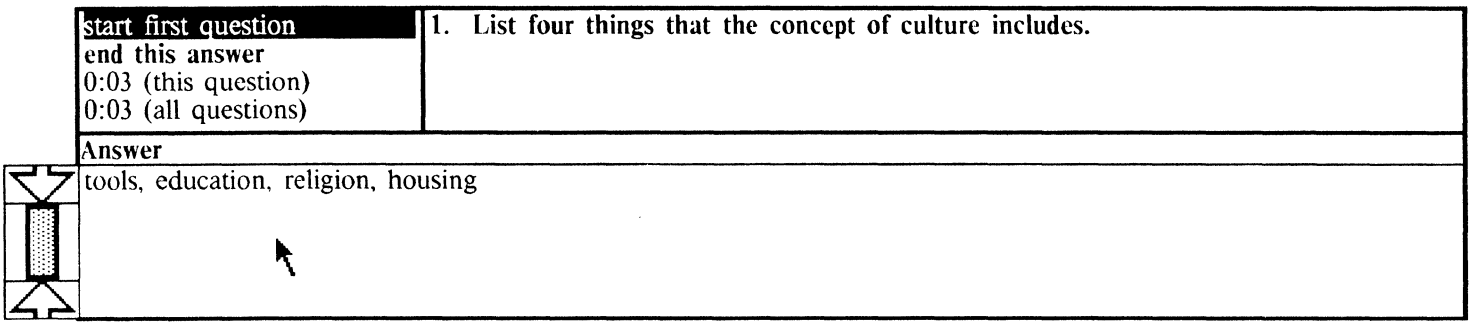
Here is the initial view of the window again (with all of its titles showing): the upper left hand pane contains two commands: **start first question**, end this answer, and two times.



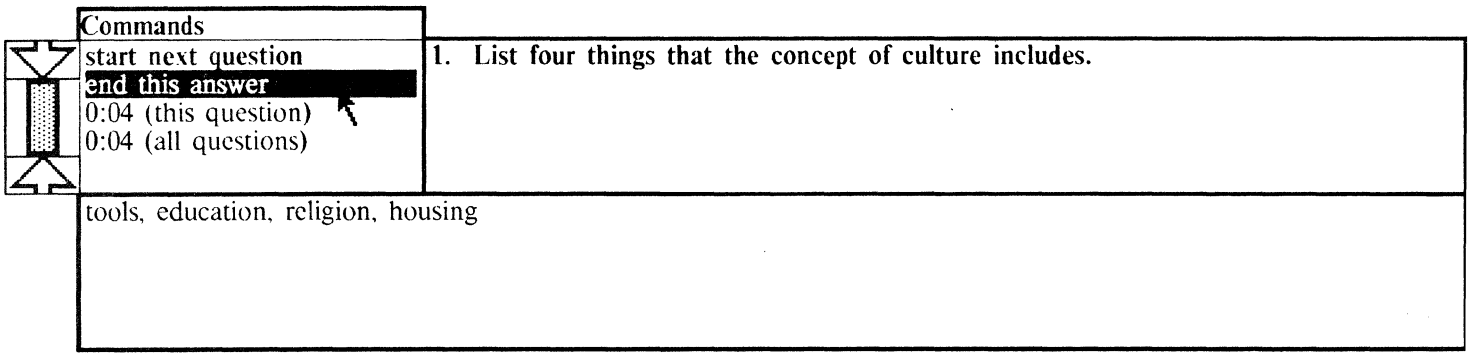
When you select the command **start first question**, it is complemented to show that it is selected, a question appears in the question pane to the right, and the previous answer (if any) is erased from the answer area.



After finding some information in either the paper or electronic or dynamic textbook, make sure the cursor is in the answer area, then type in your answer. It might then look like



When finished typing your answer, select **end this answer** in the Commands area. When you are ready for the next question, select **start next question**.



Looking for Information in the Paper Textbook

In answering the previous question, you might use the subject index at the back of the book to look up a subject term, such as "culture." When you have found a subject and its associated page number(s), you could then refer to that place in the text. Of course, you might find that your terms are not directly listed in the subject index, and you may have to try a synonym, or make the term more general or more specific, or think of some other way to find the information that you want. You may be able to use the table of contents to locate a chapter in the book, and then look at the section and sub-section headings and scan through the material. You may need to look in several places in the book in order to find the information that will satisfy the question. Sometimes the text will contain references such as (see page 000). You should ignore these.

Cui, Cesar, 477
Cuneiform, 25-26
Culture, defined, 3
Cuzco, 230, 231
Cyprus, 599
British in, 480, 515
Turkish-Greek war over, 607

On the left is a portion of the subject index containing "culture." Below is part of page 3 from the text book. One of the paragraphs contains information adequate to answer the question discussed in the previous examples.

3

Choukoutien cave and that the animals often succeeded in driving the people out. In these layers there were no charred bones to indicate that when the people occupied the cave they had fire.

Then at a certain layer, human bones took over permanently, suggesting that the people had at last won out. At this layer charred bones told that these people had discovered fire. They were using fire to keep huge animals out of the cave and to cook the meat of the animals they had killed.

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Artifacts--such human-made objects as a simple hand tool or an arrowhead--tell archaeologists something about a people's skills. Archaeologists also deal with fossils, which include not only bones but also traces of bones, footprints, and leaves left in mud that eventually turned to stone. They also study living sites, places where humans remained for a time, leaving behind bones, charcoal, and evidence of tools. From bits and pieces of evidence, archaeologists fit together a picture of what a group of people in the distant past might have been like.

Archaeologists are interested in all evidence of a culture. Culture means a people's way of life that reflects how they satisfy their needs within a certain environment. Culture includes the kind of shelter a people use, the way they obtain food, their religious ideas and practices, the kinds of tools and weapons they use, and how they communicate and pass on knowledge to children.

Pioneers on Earth.

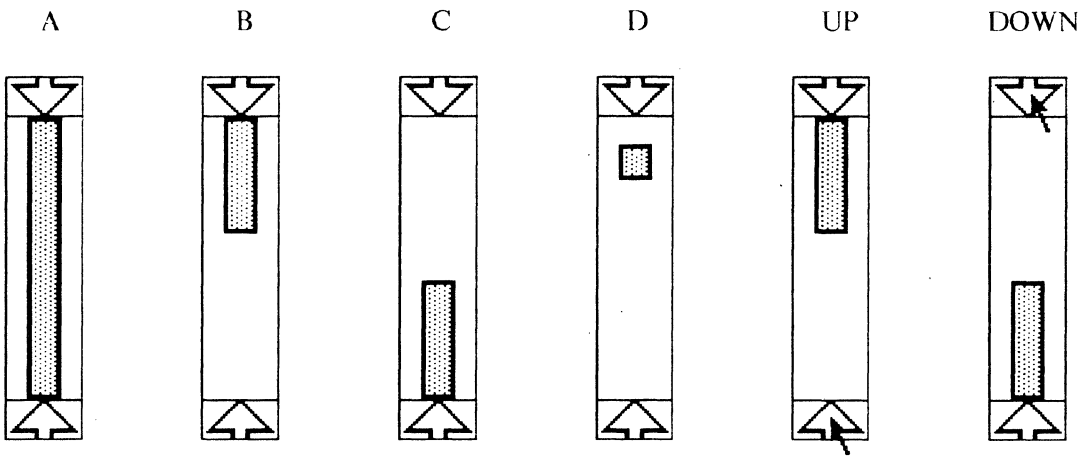
Prehistoric human fossils and artifacts have been found in many parts of the world. The people they represent truly were pioneers. They had to learn to cope with environments that, with respect to climate, vegetation, and animal life, were sometimes unfriendly. They had to develop some means of verbal communication.

Which items are visible in a pane?

The *scrollbar* appearing on the left of an active pane contains a downward arrow at the top, an interior gray rectangle, and an upward arrow at the bottom (see the Figures below for some examples). A scrollbar is useful both for knowing which items of the pane are visible (the gray rectangle), and for changing which items are visible (the arrows).

For example, in Figure A, the gray rectangle fills the entire bar, indicating that all of the items are visible. Figure B indicates that you are seeing the first part of the list, somewhat less than half. The scrollbar in Figure C indicates that you are seeing the last part of the list, somewhat less than half. In Figure D, you are seeing a "small" portion of the list, somewhere near the beginning.

The top of this gray rectangle corresponds to the location of the first visible item in the pane in the possible list of items. The bottom of the rectangle corresponds to the location of the last visible item. In other words, the location and size of the rectangle indicates approximately where you are in the list and how much of the list is visible.

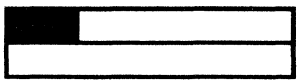


Changing which items in the pane are visible.

By selecting the upward arrow at the bottom of the scrollbar, you can move the list up by one item: the top item disappears and a new item appears at the bottom. By holding down the select button, you can continue to scroll the contents of the pane up one line at a time. Of course, once the bottom of the gray rectangle reaches the top of the arrow, you know that there are no more items below. Similarly, by selecting the downward arrow at the top of the scrollbar, you can move the list down.

In the following section, each pane is described in a little more detail. It may be useful to identify the locations of these panes on the accompanying figures.

The panes labeled Commands, Question, and Answer are used to select and see the first (or next) question, to enter an answer, and to indicate when you are finished with the current answer. You will find the information you need to answer the question in the paper textbook.

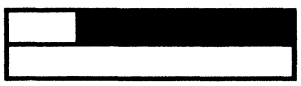


Commands

To see the first question, select the command **start first question**. A question will appear on the right and an empty area will appear for your answer below. The times in hours and minutes that have elapsed while you have been answering the current question and also for all questions also appears.

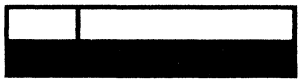
After you have found the information you need and have typed in an answer, select the command **end this answer**. Then, when you are ready for the next question, select the command **start next question**.

The system indicates which command it is expecting you to select next by displaying it in **bold** face, i.e., before you start, **start first question** appears in bold until you have selected it. Then, **end this answer** appears in bold. Then, **start next question** will appear etc. The system will automatically stop giving you questions when you are finished. If you need to take a break, do it just after selecting **end this answer**, so that the break time will not be added to the time for actually answering the question.



Question

When **start first question** (or **start next question**) is selected in Commands, a new question appears in bold face. The questions are numbered -- there are 20 all together. Now look for information in the information source provided, and type an answer in the Answer pane.



Answer

To enter an answer, move the cursor into this pane and start typing. If you are a fast typist, characters may not be displayed as quickly as you type. If this occurs, you can wait a second or two for the system to catch up with you. For correcting mistakes, you can use the BS (backspace) key to erase a single character. If you need to erase many characters, you can hold down the CTRL key and press W (which we'll designate as CTRL-W) to erase a word. CTRL-X will erase everything so that you can start over with your answer. If the answer becomes long, you can scroll the answer area up and down using the scrollbar. You can stop your typing to look for other information, and come back to add more to your answer. When you're finished with your answer, select **end this answer** in the Commands area.

Appendix B

Student Guide for Book B (the "electronic" book)
(include Appendix A except for last two pages)

Looking for Information in an Electronic Textbook

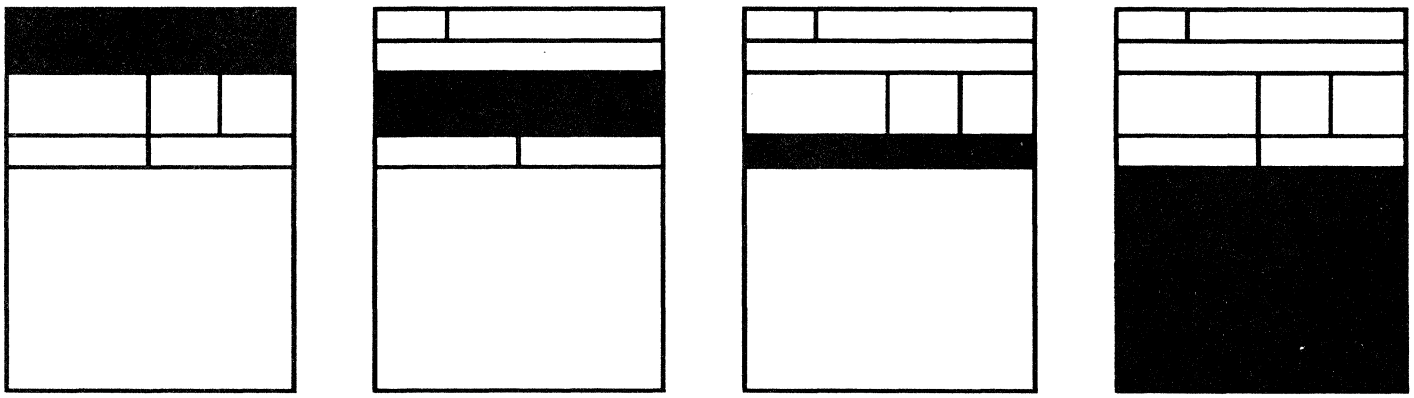
The Figures on the following pages show an initial view of the electronic version of the textbook after a question has been selected, and then illustrate how you might go about using the electronic textbook to find an answer to the question.

Note that in addition to the top area, which is the same as in the preceding figures, there are additional areas for subjects, titles, and text.

The subject area allows you to look up subject terms in the electronic textbook somewhat in the same way that you might use the subject index at the back of a standard book.

The page area allows you to access parts of the book somewhat in the same way that you might use the table of contents or to go through the book page by page.

The text area displays a portion of the textbook.



Command Area | Subject Area | Page Area | Text Area

The figure on the next page shows the result of selecting a question. The answer area is cleared for your next answer and the next question is displayed. The panes containing List of Subjects and List of Pages are cleared, and the panes containing Subject Index and the Page Index are set at the beginning. The Subject Index contains the alphabetic list of subject items from the back of the standard book. The Page Index gives you a set of page numbers you may wish to select.

Commands	Question
start first question end this answer 0:00 (this question) 0:00 (all questions)	1. List four things that the concept of culture includes.

Answer

List of Subjects	Subject Index	Sub-Subject Index
	Aahotep Abbassids Abd-al-Rahman, caliph of S Abelard, Pierre Abraham Abstract expressionism Abu Saheli Abu-Bakr Abyssinia Acropolis	

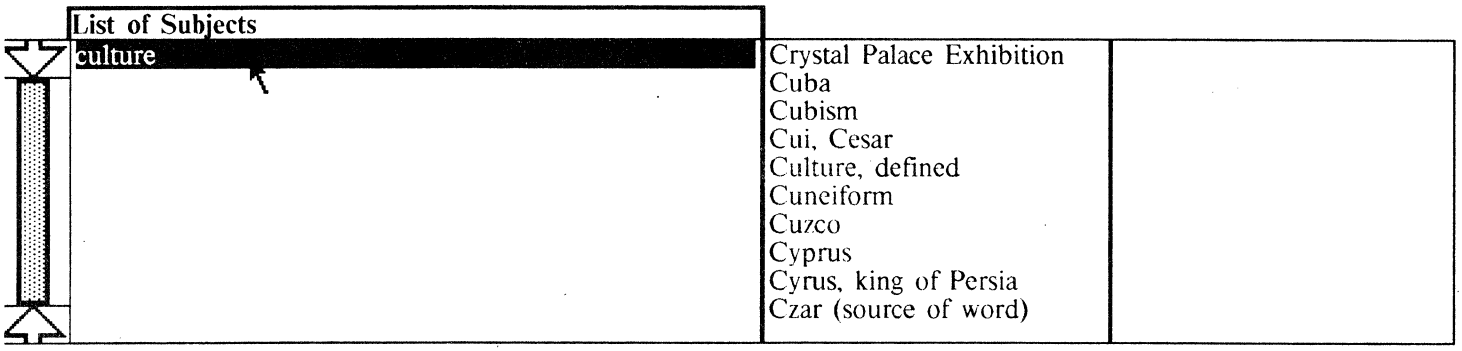
List of Pages	Page Index
	1 2 3 4

Text

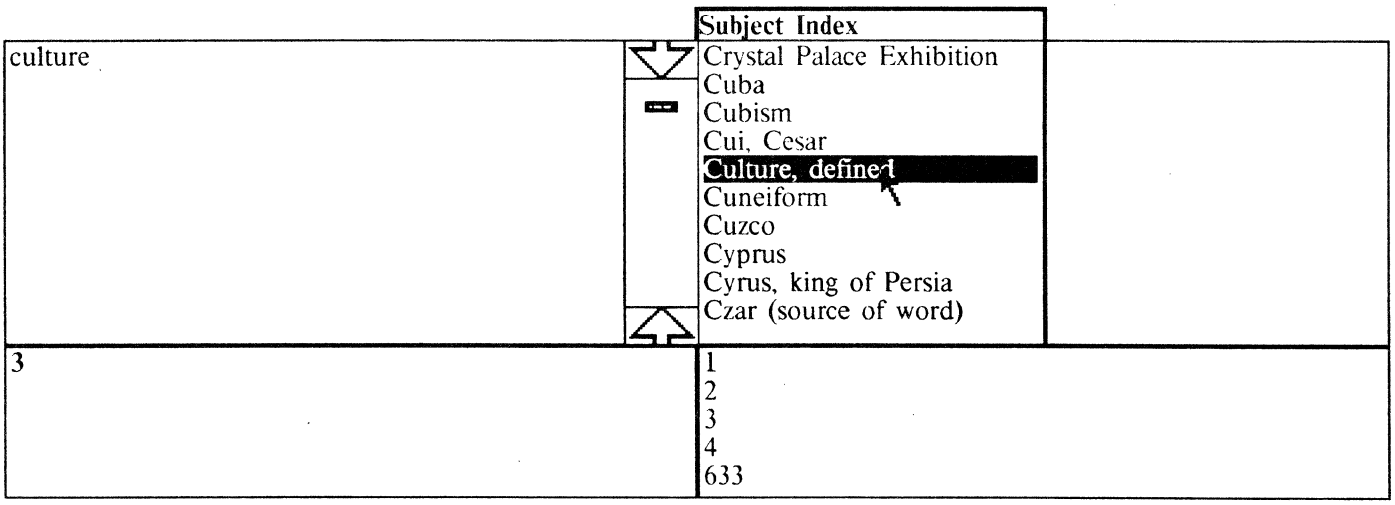
Answering a Question using the Electronic Textbook

Given the question: "List four things that the concept of culture includes," you might start by looking up "culture" in the subject index.

In the Figure below, which is a portion of the entire window, you can see the result of typing "culture" in the List of Subjects area: the Subject Index on the right is positioned to show Culture at the center of the list.



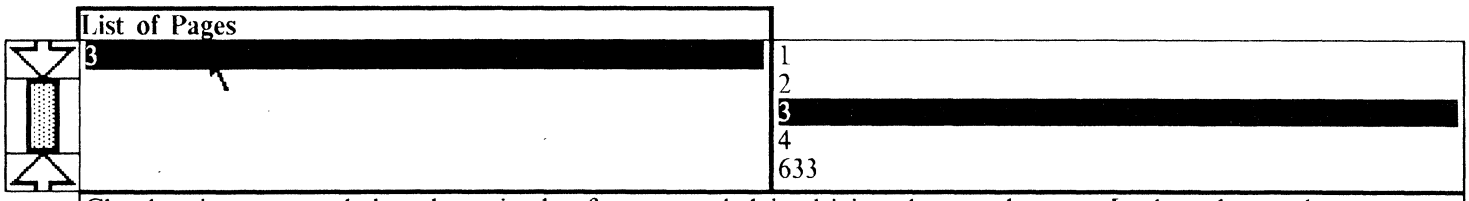
The Figure below shows the result of selecting the item "Culture, defined": a page number is displayed in the List of Pages, below and to the left of the Subject Index.



In the Figure below, you can see the result of selecting that page. The Page Index is positioned to that page, and the text is displayed in the Text Area. Notice also that every instance of word(s) in the selected subject are displayed in the text in bold face (in this case the word **culture** is bolded). This will help you in finding occurrences of those words, which may lead you more quickly to finding a suitable answer.

To see a different page, you could select the previous or next page number in the Page Index, or type or select a page number in the List of Pages.

The Figure on the next page shows what the window looks like after you have entered your answer, and selected **end this answer**.



Choukoutien cave and that the animals often succeeded in driving the people out. In these layers there were no charred bones to indicate that when the people occupied the cave they had fire.

Then at a certain layer, human bones took over permanently, suggesting that the people had at last won out. At this layer charred bones told that these people had discovered fire. They were using fire to keep huge animals out of the cave and to cook the meat of the animals they had killed.

Archaeologists are the chief investigators in such an enterprise. They are concerned with uncovering and studying evidence of life in prehistoric times. This was the period of hundreds of thousands of years before humans learned to write and record their thoughts and deeds.

Artifacts--such human-made objects as a simple hand tool or an arrowhead--tell archaeologists something about a people's skills. Archaeologists also deal with fossils, which include not only bones but also traces of bones, footprints, and leaves left in mud that eventually turned to stone. They also study living sites, places where humans remained for a time, leaving behind bones, charcoal, and evidence of tools. From bits and pieces of evidence, archaeologists fit together a picture of what a group of people in the distant past might have been like.

Archaeologists are interested in all evidence of a **culture**. **Culture** means a people's way of life that reflects how they satisfy their needs within a certain environment. **Culture** includes the kind of shelter a people use, the way they obtain food, their religious ideas and practices, the kinds of tools and weapons they use, and how they communicate and pass on knowledge to children.

Pioneers on Earth.

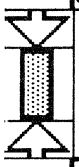
Prehistoric human fossils and artifacts have been found in many parts of the world. The people they represent truly were pioneers. They had to learn to cope with environments that, with respect to climate, vegetation, and animal life, were sometimes unfriendly. They had to develop some means of verbal communication. They had to discover sources of food and how to fashion tools and clothing from materials on hand, at first learning as they went. And, for the group to survive, they had to pass on their knowledge to their children.

Fire was a primary tool, and no one knows how humans first acquired it. Fire offered a means to render meat more tender and tasty. It helped protect humans against wild beasts. Used to ignite a dried grassland, it could frighten animals toward a place where hunters lay in wait. And fire, of course, conquered the darkness of caves and the night.

Migrations.

It is likely that the earliest humans lived in such tropical regions as central Africa and Java, where the climate was warm the year-round. They were hunters of animals and gatherers of fruits, nuts, seeds, and roots. It appears that humans gradually spread out from these areas over long periods of time into northern Africa and into Europe and Asia.

There probably were no mass movements of people. Bands of early humans were small, of necessity. A single hunter probably needed ten square miles to find sufficient game to feed one person. A band of thirty people would require three hundred square miles of territory. Early humans probably established more or less per



Commands

start next question
end this answer
0:04 (this question)
0:04 (all questions)

1. List four things that the concept of culture includes.

tools, education, religion, housing

culture

Crystal Palace Exhibition
Cuba
Cubism
Cui, Cesar
Culture, defined
Cuneiform
Cuzco
Cyprus
Cyrus, king of Persia
Czar (source of word)

3

1
2
3
4
633

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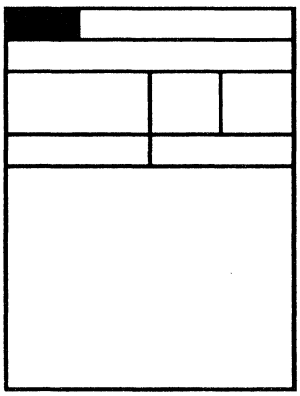
The panes labeled Commands, Question, and Answer are used to select and see the first (or next) question, to enter an answer, and to indicate when you are finished with the current answer. You will find the information you need to answer the question in an electronic version that appears in the other panes in the window.



Commands

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After you have found the information you need and have typed in an answer, select the command **end this answer**. Then, when you are ready for the next question, select the command **start next question.**

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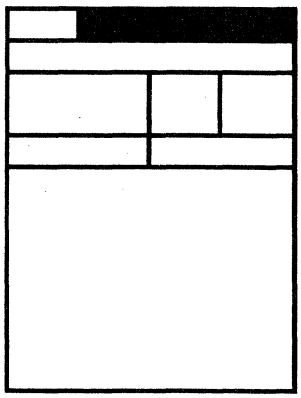
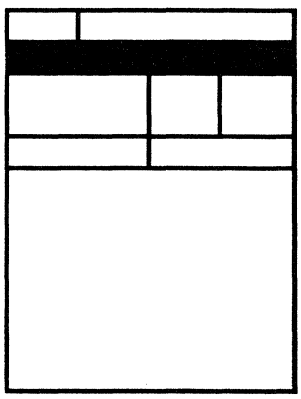


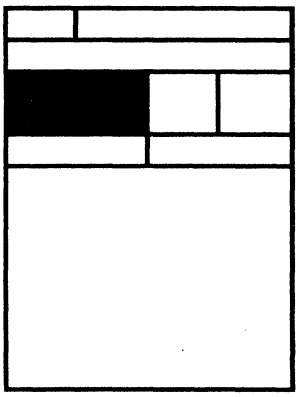
Question

When **start first question** (or **start next question)** is selected in Commands, a new question appears in bold face. The questions are numbered -- there are 20 all together. Now look for information in the information source provided, and type an answer in the Answer pane.



Answer

To enter an answer, move the cursor into this pane and start typing. If you are a fast typist, characters may not be displayed as quickly as you type. If this occurs, you can wait a second or two for the system to catch up with you. For correcting mistakes, you can use the BS (backspace) key to erase a single character. If you need to erase many characters, you can hold down the CTRL key and press W (which we'll designate as CTRL-W) to erase a word. CTRL-X will erase everything so that you can start over with your answer. If the answer becomes long, you can scroll the answer area up and down using the scrollbar. You can stop your typing to look for other information, and come back to add more to your answer. When you're finished with your answer, select **end this answer** in the Commands area.



List of Subjects

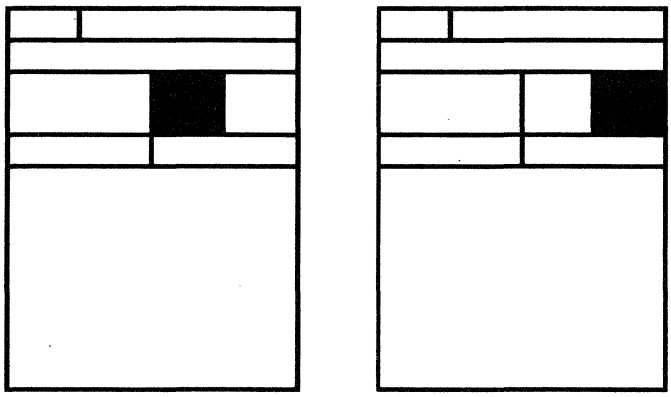
One way to locate places of interest in the book is to use the Subject Index. The List of Subjects contains subject terms such as "Culture" or compound subject terms such as "Religion:Inca." When you select a subject item in the List of Subjects, the system will select it in the Subject Index panes (or at least position it to the nearest alphabetical entry). Conversely, when you select a subject in the Subject Index, the system will usually select it in the List of Subjects, if it's present.

Typing in the List of Subjects area or in the Subject Index area is probably the most common way to add items to the List of Subjects. Use BS to backspace characters. Type the RETURN key or use the SELECT button on the mouse to indicate that you're finished. If you erased all of the characters, no item will be added. Typing a partial item, e.g., "Charlem," will position the Subject Index to the appropriate area of the alphabet.

Pressing the middle mouse button "ADD/MARK" in the Subject Index area will add an item to the List of Subjects. You can now refer back to that subject by just selecting it. If a subject item appears in the list in **bold** face, it's just a reminder that you haven't looked at that subject item yet. This will occur only if you add a subject cross reference (an italicized entry) to the subject list. For example, when Abysinnia is selected in the Subject Index, it displays *Ethiopia* in the Subject Index pane on its right. If you add this to the List of Subjects, **Ethiopia** will appear bolded; when later selected, it will appear unbolded.

If a subject item appears underlined in the List of Subjects, it means you accidentally pressed the "ADD/MARK" button. Marked items will be described in a later section. To delete a marked or unmarked item, use the rightmost mouse button "DELETE."

A note about alphabetical conventions:
Last name, First Name (for a person's name)
Bible, The ("the" never occurs at the beginning)
Ch'in dynasty comes before Chang dynasty
de Soto comes before Denmark (spaces are significant)
accent marks, umlauts, and italics are not included



Subject Index

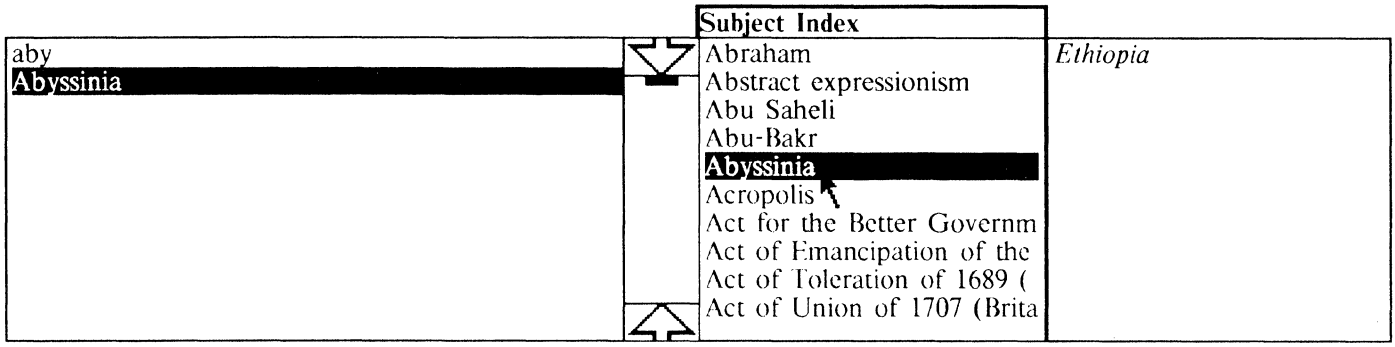
To bring different portions of the subject index into view, you can either scroll up or down one line at a time using the arrows at the top and bottom of the scrollbar (this is recommended only for short jumps), or by typing in some of the first letters of the subject that you are looking for. As mentioned above, this typing appears in the List of Subjects and is terminated by RETURN or by depressing the left mouse button ("SELECT").

After you select a subject, a further breakdown of the subject may appear in the Subject Index pane on its right (Sub-Subject Index). A list of pages that are associated with the general subject may also appear in the List of Pages area. You can add the current subject to the List of Subjects for later reference by pressing the "ADD/MARK" mouse button. The subject term may or may not be compound, i.e., it may contain embedded colons (":") depending on which pane you are in. The further you are to the right, the more colons may appear (e.g., Religion:Inca).

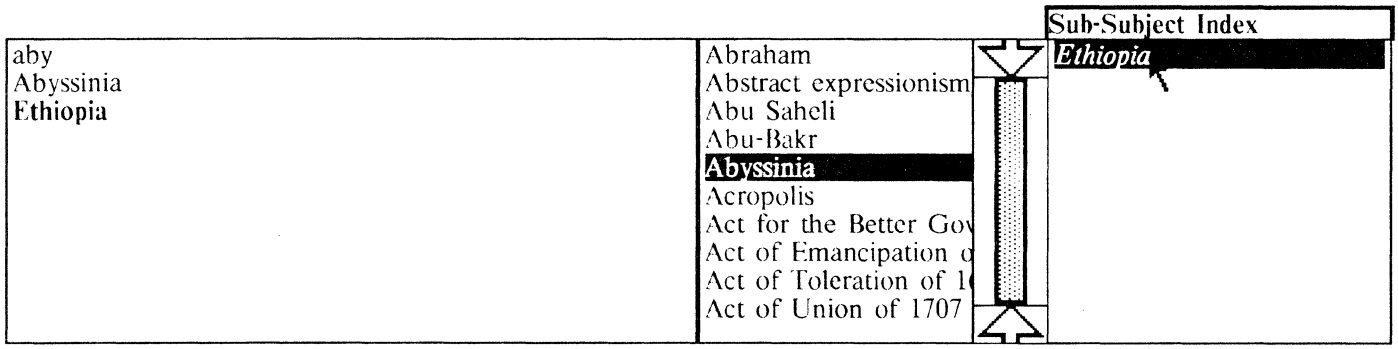
The list in the Sub-Subject Index pane might not be strictly alphabetical (i.e., ordered by the initial characters). It may contain *cross references* to other subjects at end of the list (e.g., under Abyssinia, *Ethiopia* would mean "see also Ethiopia," but the words "see also" don't appear). You can add the current compound subject to the List of Subjects, and you can also add a *cross reference* for later selection.

Using ADD in the Subject Index

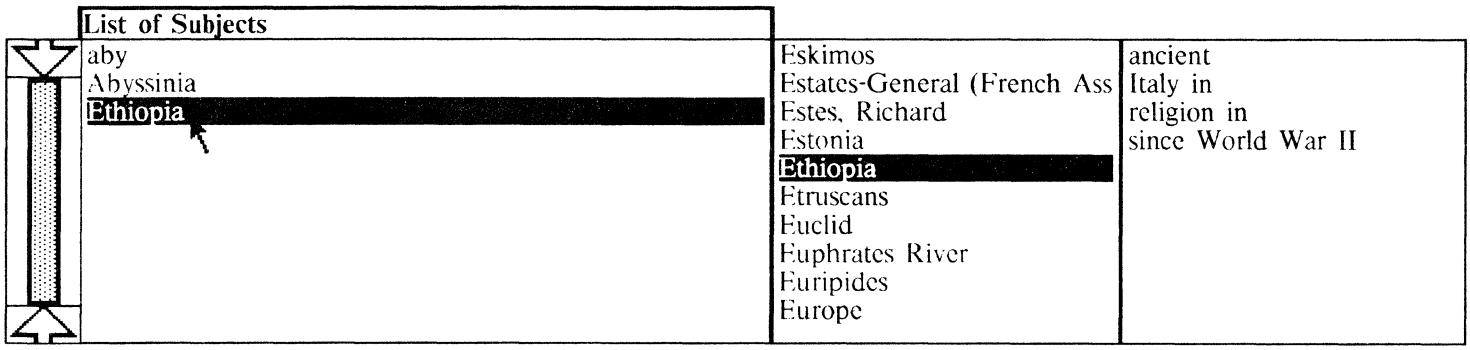
In the Figure below, "aby" was typed in the List of Subjects, and "Abyssinia" was selected in the Subject Index. Then, "Abyssinia" was added to the List of Subjects (by pressing the "ADD/MARK" button). Note the appearance of *Ethiopia* in the Sub-Subject Index.

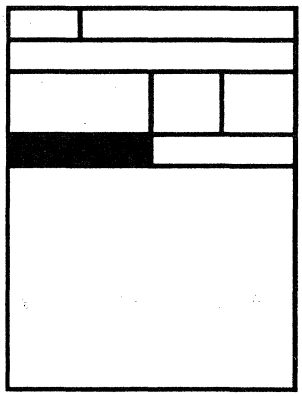


The next Figure shows the result of selecting "Ethiopia" in the Sub-Subject Index and adding it to the List of Subjects.



The last Figure shows the result of selecting "Ethiopia" in the List of Subjects.



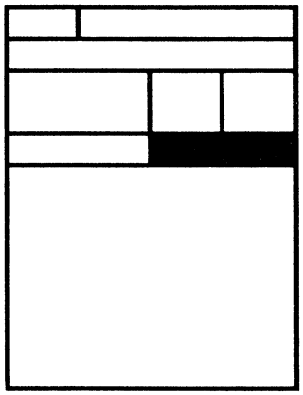


List of Pages

The page numbers associated with a given subject appear in the List of Pages area. Selecting a page number (or beginning of a page number range), causes the appropriate page number to be selected in the Page Index on the right. Page numbers in the Page Index can be added to the List of Pages. You can also type in new page numbers in the List of Pages or Page Index, and the book will be turned to that page. Same typing conventions as for the List of Subjects.

Because selecting a subject in the Subject Index replaces the pages in the List of Pages, sometimes you'll lose a page that you wanted to refer to again. In order to save a page, press the "ADD/MARK" button on the mouse, and it will be marked -- this is somewhat similar to leaving a bookmark in the book at a particular page. It will not be deleted when a new subject is selected. In order to get rid of a marked page, select the "DELETE" button on the mouse.

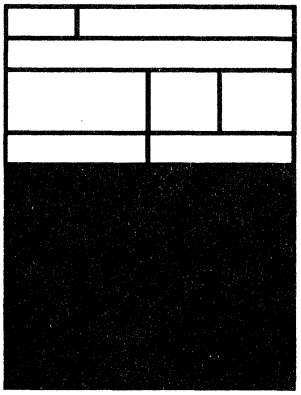
If a new page is the same as an older marked one, the old page will appear both bold and underlined. New pages will appear **bold**. Old marked pages will be just underlined.



Page Index

Selecting a page number will cause the text for that page to be displayed in the Text Area. In addition to displaying the current page number, the Page Index displays the first and last page numbers, and some page numbers adjacent to the current page. To choose a page number different from those visible in the Page Index, select that page number from the List of Pages, or type a page number in the List of Pages or Page Index area (terminated by RETURN on the keyboard, or SELECT on the mouse).

You can add the currently selected page number to the List of Pages by pressing the "ADD/MARK" mouse button.



Text Area

This area displays a textual portion of the book. If all of the text is not visible, you can use the scrollbar on the left to move the text up.

Usually any words that exactly match the words selected in the Subject Index are emphasized or highlighted in **bold**. Certain common words such as "the" are not highlighted. Differences between UPPER and lower case characters are ignored. This, of course, will show you where people's names are mentioned and where specific subject phrases occur. However, it does exact matching of words, not phrases or word roots. This exact matching means that a word can be highlighted in different contexts (e.g., all uses of the word "king," not just "king" next to "arthur"). It also means that "war" as a subject term will not cause "wars" to be highlighted in the text, and vice versa.

Sometimes the text contains a reference such as "see page 000" -- you should ignore these.

```
ESC  1  2  3  4  5  6  7  8  9  0  -  =  \  LF  DEL
 TAB  Q  W  E  R  T  Y  U  I  O  P  [  ]  ←  BS
 CTRL  A  S  D  F  G  H  J  K  L  ;  '  RETURN
LOCK SHIFT Z  X  C  V  B  N  M  ,  .  /  SHIFT
```

Keyboard

You can type in the Answer pane, the List of Subjects and Subject Index panes, and in the List of Pages and Page Index Panes. BS (backspace) erases a single character. RETURN will end selections.

Bold Face

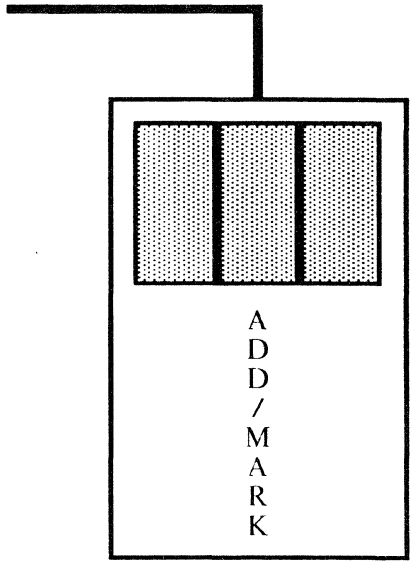
Bold face characters may be found in the List of Subjects pane to signify new subject terms, such as added subject cross references. New page numbers are displayed in bold in the List of Pages. Significant words from the current subject phrase are boldly displayed in the Text area. The question in the Question pane and the "next" command in the Command pane are displayed in bold. The titles of panes appear in bold.

Marked items

Subjects in the List of Subjects can be marked, i.e., made "permanent." Typically though, this is of main use in the List of Pages area for holding onto Page references that might otherwise disappear when you select a new subject.

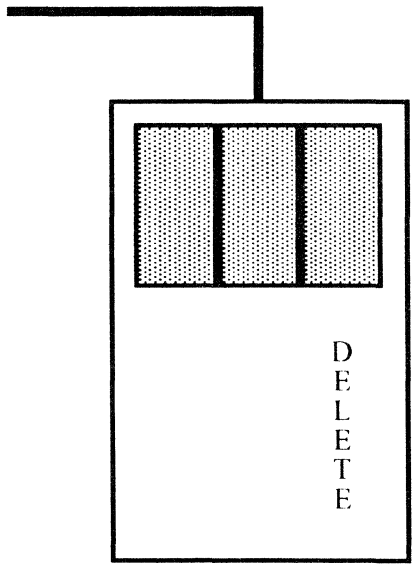
Subject cross references

These may appear as "see also" references in the Sub-Subject Index pane. Subject cross references are italicized and may be added to the List of Subjects.



ADD/MARK

The middle mouse button can be used to add the currently selected subject or compound subject from the Subject Index to the List of Subjects. Subjects in the List of Subjects can be marked. You can also add Page references from the Page Index to the List of Pages. Pages in the List of Pages can be marked.



DELETE

Use the rightmost mouse button to delete the current selection from the List of Subjects or List of Pages. Delete will get rid of both marked and unmarked entries.

Appendix C

Student Guide for Book C (the "dynamic" book)
(include Appendix A except for last two pages)

Looking for Information in a Dynamic Textbook

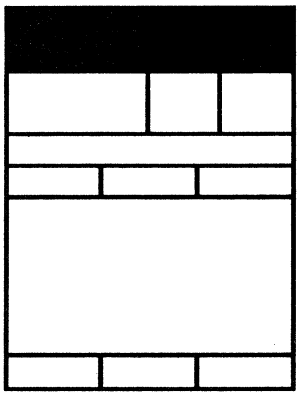
The Figures on the following pages show an initial view of the dynamic version of the textbook after a question has been selected, and then illustrate how you might go about using the dynamic textbook to find an answer to the question.

Note that in addition to the top area, which is the same as in the preceding figures, there are additional areas for subjects, titles, and text.

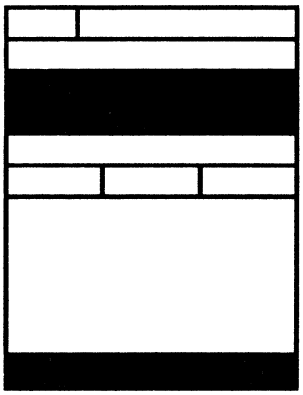
The subject area allows you to look up subject terms in the dynamic textbook somewhat in the same way that you might use the subject index at the back of a standard book.

The title area allows you to access parts of the book somewhat in the same way that you might use the table of contents or to go through the book section by section.

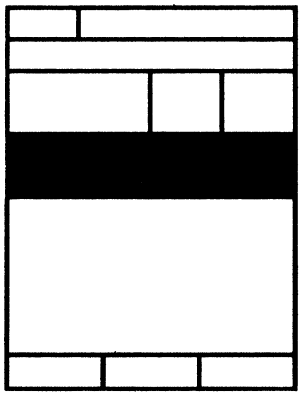
The text area displays a portion of the textbook.



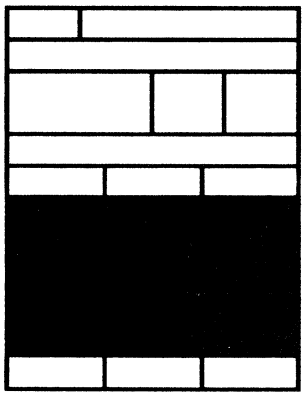
Command Area



Subject Area



Title Area



Text Area

The figure on the next page shows the result of selecting a question. The answer area is cleared for your next answer and the next question is displayed. The panes containing List of Subjects and List of Titles are cleared, and the panes containing Subject Index and the Title Index (Chapters, Sections, and Sub-Sections) are set at the beginning. The Subject Index contains the alphabetic list of subject items from the back of the standard book. The pane labeled Chapters contains the chapter headings that would be found in the table of contents of the standard book.

Commands	Question
start first question end this answer 0:00 (this question) 0:00 (all questions)	1. List four things that the concept of culture includes.

Answer

List of Subjects	Subject Index	Sub-Subject Index
	Aahotep Abbassids Abd-al-Rahman, caliph of S Abelard, Pierre Abraham Abstract expressionism Abu Saheli Abu-Bakr Abyssinia Acropolis	

List of Titles

Chapters	Sections	Sub-Sections
Prologue - Prehistoric Peoples: Pione OVERVIEW Interacting Civilizations in the Middle Egyptian Civilization in the Nile Valle		

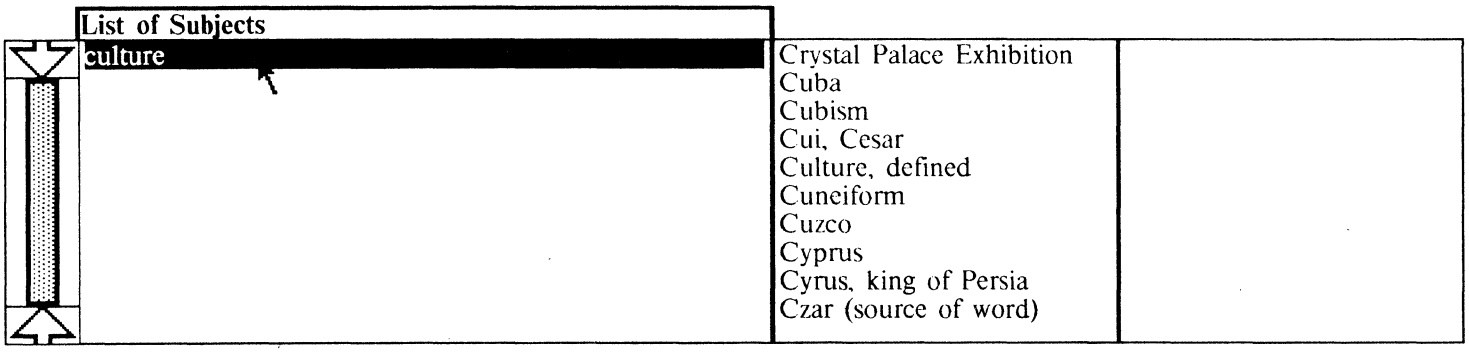
Text

Subject References (Chapter)	Subject References (Section)	Subject References (Sub-Section)

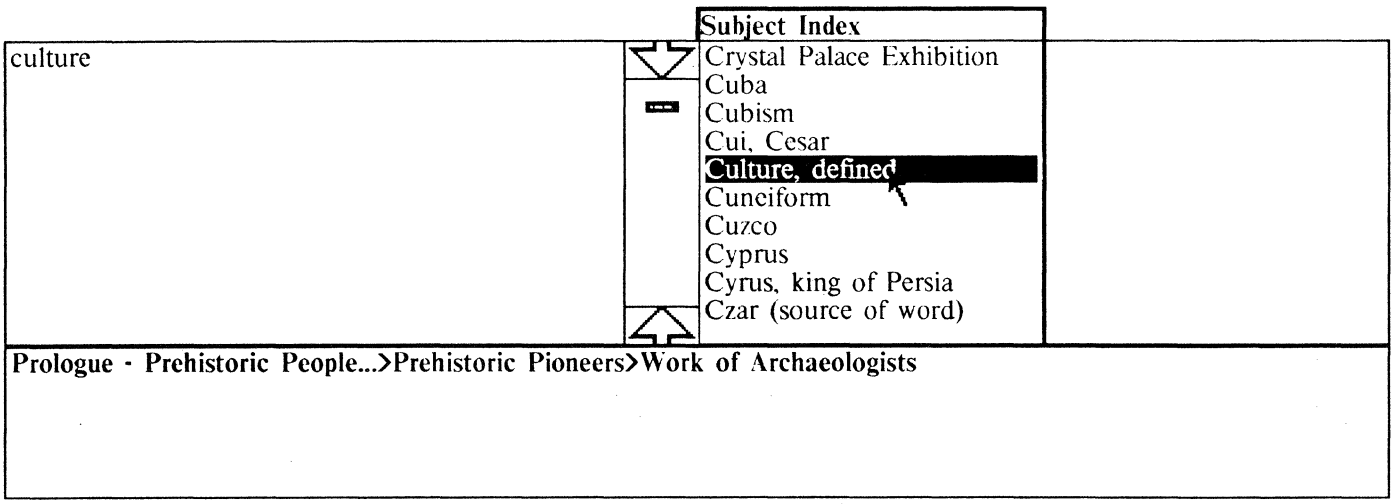
Answering a Question using the Dynamic Textbook

Given the question: "List four things that the concept of culture includes," you might start by looking up "culture" in the subject index.

In the Figure below, which is a portion of the entire window, you can see the result of typing "culture" in the List of Subjects area: the Subject Index on the right is positioned to show Culture at the center of the list.



The Figure below shows the result of selecting the item "Culture, defined." Instead of a page number, a title is displayed in the List of Titles below it.

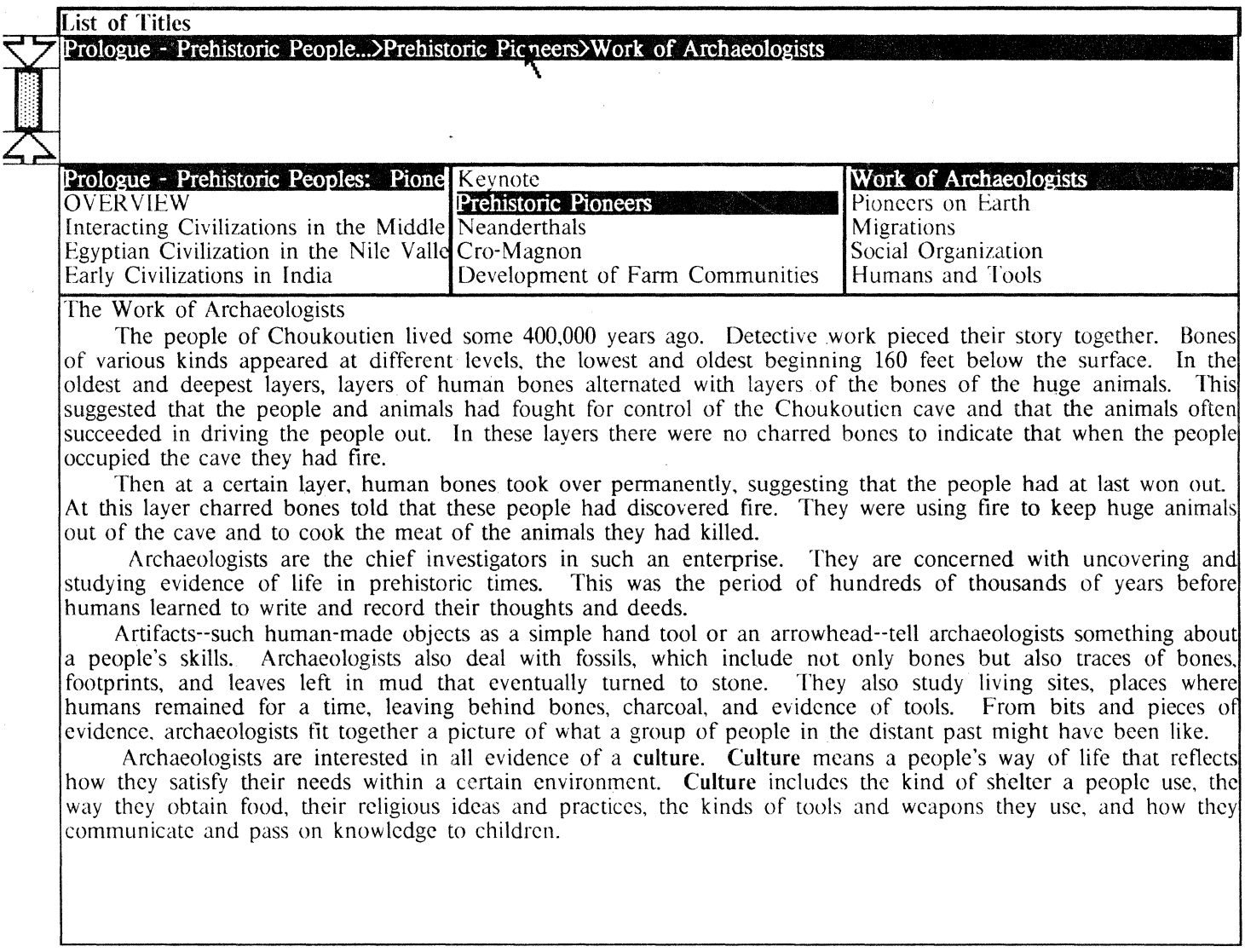


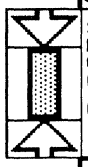
In the Figure below, you can see the result of selecting that title. The Title Index (Chapters, Sections, and Sub-Sections) is positioned to that title, and the text is displayed in the Text Area. Notice also that every instance of word(s) in the selected subject are displayed in the text in bold face (in this case the word **culture** is bolded). This will help you in finding occurrences of those words, which may lead you to finding a suitable answer more quickly.

You may select any chapter, section, or sub-section in one of the Title Index panes or select another title from the List of Titles.

The Figure on the next page shows what the window looks like after you have entered your answer, and selected **end this answer**.

In addition, some Subject References are visible below the Text Area. More about those later.





Commands	1. List four things that the concept of culture includes.
start next question end this answer 0:04 (this question) 0:04 (all questions)	

tools, education, religion, shelter

culture	Crystal Palace Exhibition Cuba Cubism Cui, Cesar **Culture, defined** Cuneiform Cuzco Cyprus Cyrus, king of Persia Czar (source of word)	

Prologue - Prehistoric People...>Prehistoric Pioneers>Work of Archaeologists

Prologue - Prehistoric Peoples: Pione	Keynote	**Work of Archaeologists**
OVERVIEW	**Prehistoric Pioneers**	Pioneers on Earth
Interacting Civilizations in the Middle	Neanderthals	Migrations
Egyptian Civilization in the Nile Valle	Cro-Magnon	Social Organization
Early Civilizations in India	Development of Farm Communities	Humans and Tools

The Work of Archaeologists

The people of Choukoutien lived some 400,000 years ago. Detective work pieced their story together. Bones of various kinds appeared at different levels, the lowest and oldest beginning 160 feet below the surface. In the oldest and deepest layers, layers of human bones alternated with layers of the bones of the huge animals. This suggested that the people and animals had fought for control of the Choukoutien cave and that the animals often succeeded in driving the people out. In these layers there were no charred bones to indicate that when the people occupied the cave they had fire.

Then at a certain layer, human bones took over permanently, suggesting that the people had at last won out. At this layer charred bones told that these people had discovered fire. They were using fire to keep huge animals out of the cave and to cook the meat of the animals they had killed.

Archaeologists are the chief investigators in such an enterprise. They are concerned with uncovering and studying evidence of life in prehistoric times. This was the period of hundreds of thousands of years before humans learned to write and record their thoughts and deeds.

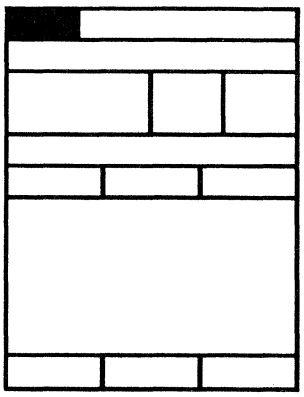
Artifacts--such human-made objects as a simple hand tool or an arrowhead--tell archaeologists something about a people's skills. Archaeologists also deal with fossils, which include not only bones but also traces of bones, footprints, and leaves left in mud that eventually turned to stone. They also study living sites, places where humans remained for a time, leaving behind bones, charcoal, and evidence of tools. From bits and pieces of evidence, archaeologists fit together a picture of what a group of people in the distant past might have been like.

Archaeologists are interested in all evidence of a **culture**. **Culture** means a people's way of life that reflects how they satisfy their needs within a certain environment. **Culture** includes the kind of shelter a people use, the way they obtain food, their religious ideas and practices, the kinds of tools and weapons they use, and how they communicate and pass on knowledge to children.

Prehistoric humans	*China:prehistoric people in* *Civilization:earliest* *Java man* *Peking man* *Women:prehistoric*	*Archaeology* *Artifacts, defined* *Choukoutien, China* *Culture, defined* *Fossils*

In the following section, each pane is described in a little more detail. It may be useful to identify the locations of these panes on the accompanying figures.

The panes labeled Commands, Question, and Answer are used to select and see the first (or next) question, to enter an answer, and to indicate when you are finished with the current answer. You will find the information you need to answer the question in a dynamic version that appears in the other panes in the window.

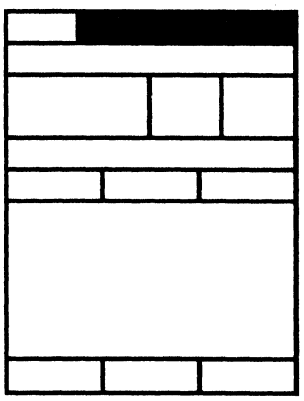


Commands

To see the first question, select the command **start first question**. A question will appear on the right and an empty area will appear for your answer below. The times in hours and minutes that have elapsed while you have been answering the current question and also for all questions also appears.

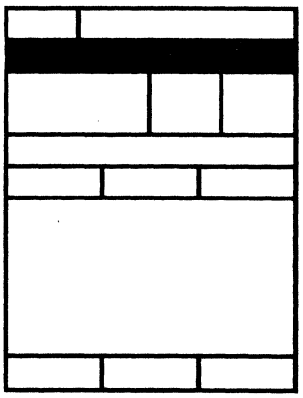
After you have found the information you need and have typed in an answer, select the command **end this answer**. Then, when you are ready for the next question, select the command **start next question**.

The system indicates which command it is expecting you to select next by displaying it in **bold** face, i.e., before you start, **start first question** appears in bold until you have selected it. Then, **end this answer** appears in bold. Then, **start next question** will appear etc. The system will automatically stop giving you questions when you are finished. If you need to take a break, do it just after selecting **end this answer**, so that the break time will not be added to the time for actually answering the question.



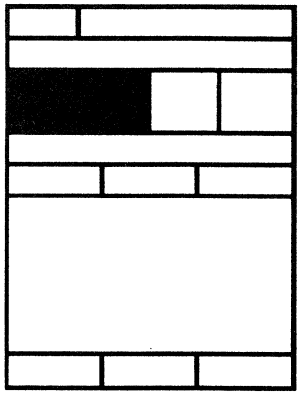
Question

When **start first question** (or **start next question)** is selected in Commands, a new question appears in bold face. The questions are numbered -- there are 20 all together. Now look for information in the information source provided, and type an answer in the Answer pane.



Answer

To enter an answer, move the cursor into this pane and start typing. If you are a fast typist, characters may not be displayed as quickly as you type. If this occurs, you can wait a second or two for the system to catch up with you. For correcting mistakes, you can use the BS (backspace) key to erase a single character. If you need to erase many characters, you can hold down the CTRL key and press W (which we'll designate as CTRL-W) to erase a word. CTRL-X will erase everything so that you can start over with your answer. If the answer becomes long, you can scroll the answer area up and down using the scrollbar. You can stop your typing to look for other information, and come back to add more to your answer. When you're finished with your answer, select **end this answer** in the Commands area.



List of Subjects

One way to locate places of interest in the book is to use the Subject Index. The List of Subjects contains subject terms such as "Culture" or compound subject terms such as "Religion:Inca." When you select a subject item in the List of Subjects, the system will select it in the Subject Index panes (or at least position it to the nearest alphabetical entry). Conversely, when you select a subject in the Subject Index, the system will usually select it in the List of Subjects, if it's present.

Typing in the List of Subjects area or in the Subject Index area is probably the most common way to add items to the List of Subjects. Use BS to backspace characters. Type the RETURN key or use the SELECT button on the mouse to indicate that you're finished. If you erased all of the characters, no item will be added. Typing a partial item, e.g., "Charlem," will position the Subject Index to the appropriate area of the alphabet.

Pressing the middle mouse button "ADD/MARK" in the Subject Index area will add an item to the List of Subjects. You can now refer back to that subject by just selecting it. If a subject item appears in the list in **bold** face, it's just a reminder that you haven't looked at that subject item yet. This will occur only if you add a subject cross reference (an italicized entry) to the subject list. For example, when Abysinnia is selected in the Subject Index, it displays *Ethiopia* in the Subject Index pane on its right. If you add this to the List of Subjects, **Ethiopia** will appear bolded; when later selected, it will appear unbolded.

If a subject item appears underlined in the List of Subjects, it means you accidentally pressed the "ADD/MARK" button. Marked items will be described in a later section. To delete a marked or unmarked item, use the rightmost mouse button "DELETE."

A note about alphabetical conventions:
Last name, First Name (for a person's name)
Bible, The ("the" never occurs at the beginning)
Ch'in dynasty comes before Chang dynasty
de Soto comes before Denmark (spaces are significant)
accent marks, umlauts, and italics are not included

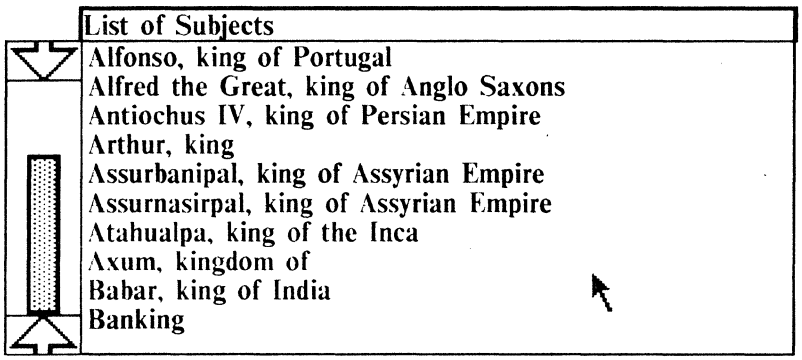
A few more details about the List of Subjects

Subject cross references from the Subject Reference panes below the Text Area can also be added to the List of Subjects.

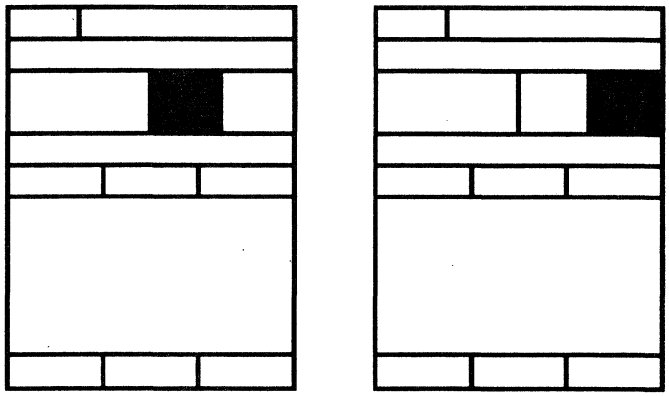
In the situation where the subject term you want can't be found alphabetically by its initial letters in the Subject Index, you may wish to try a *pattern.* A pattern is a sequence of characters that partially specifies what you want, and also what you don't care about. For example, "King" is not a subject term, but typing a pattern such as "*King*" in the List of Subjects area would expand into a list of all subject items that contain the characters "King," preceded and followed by anything else. This would include, for example, "Charles, King of England." However, it would also include "Banking" and "Middle Kingdom, the." To avoid these, you might have to modify the pattern to contain spaces to indicate that King is really a separate word, for example, "* King *," or perhaps even better, "*king of England*." Sometimes a year is mentioned as part of a subject term and you can search for that, e.g., *1670*. Before resorting to this kind of search though, because it is somewhat time consuming, you might first try other terms that might be listed alphabetically.

As the system discovers subject terms which match your pattern, these are added to the List of Subjects in **bold** face. If you think there will be too many subject items because the pattern is too general, or you've found the subject term that you want, and you don't want the system to find you any more subjects, type the DEL key. For example, if you had typed "*" as your pattern, the system would give you all of the items in the Subject Index unless you stopped it!!! Even the pattern "* king *" mentioned above would yield too many items for you to examine.

Special characters that can be included (for pattern match) are # (pound sign), which matches any single character, and * (asterisk), which matches from zero to any number of characters. Both of these characters can be included anywhere in the subject pattern, and can occur more than once. However, a * or # included as the first character of the pattern may take a minute or so to process as the number of subject that have to be checked will be large. Some examples: "dog*" would match "dog," "dogs," "dog's," "dogma"; "see#" would match "seen," "seed," "seem," "seer," etc., but not "see" or words longer than 4 letters beginning with see.



On the left is the partial result for the pattern "*king*."



Subject Index

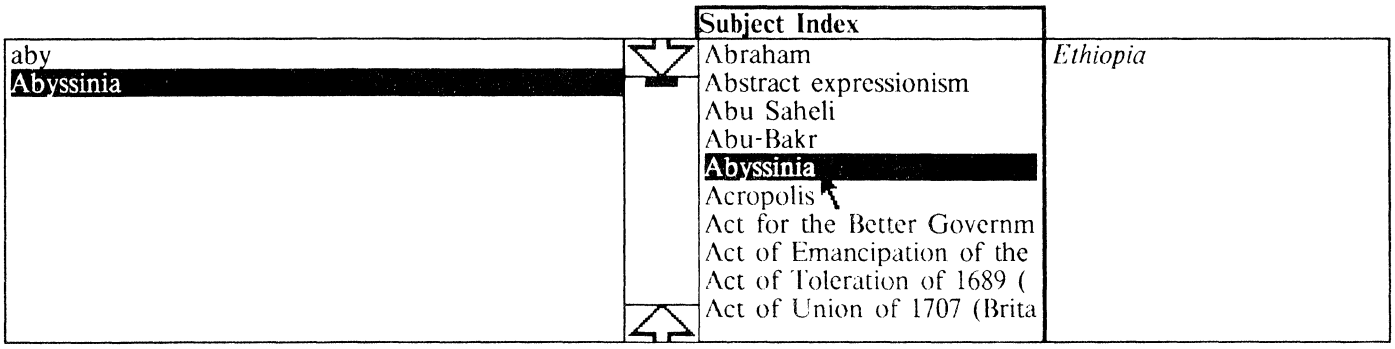
To bring different portions of the subject index into view, you can either scroll up or down one line at a time using the arrows at the top and bottom of the scrollbar (this is recommended only for short jumps), or by typing in some of the first letters of the subject that you are looking for while the cursor is in the subject area. This typing appears in the List of Subjects and is terminated by RETURN or by depressing the left mouse button ("SELECT").

After you select a subject, a further breakdown of the subject may appear in the Subject Index pane on its right (Sub-Subject Index). A list of titles that are associated with the general subject may also appear in the List of Titles area. You can add the current subject to the List of Subjects for later reference by pressing the "ADD/MARK" mouse button. The subject term may or may not be compound, i.e., it may contain embedded colons (":") depending on which pane you are in. The further you are to the right, the more colons may appear (e.g., Religion:Inca).

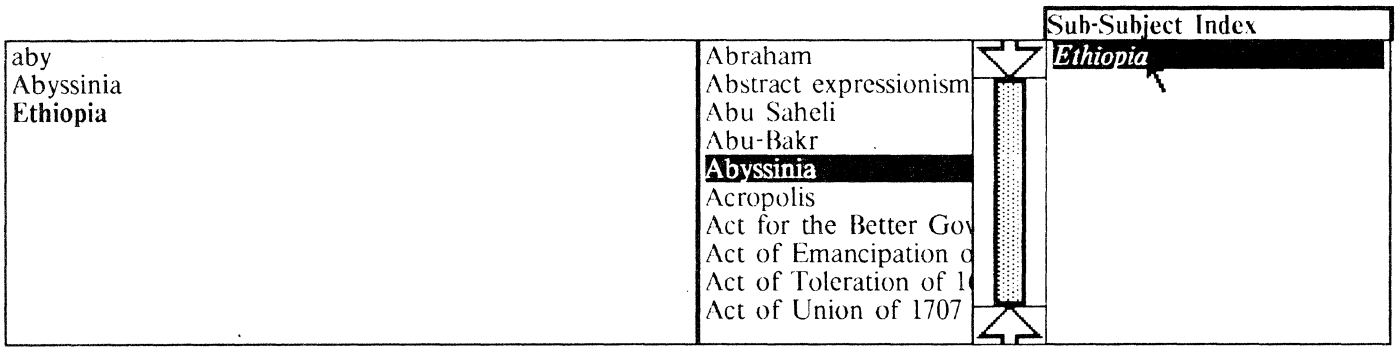
The list in the Sub-Subject Index pane might not be strictly alphabetical (i.e., ordered by the initial characters). It may contain *cross references* to other subjects at end of the list (e.g., under Abyssinia, *Ethiopia* would mean "see also Ethiopia," but the words "see also" don't appear). You can add the current compound subject to the List of Subjects, and you can also add a *cross reference* for later selection. On the next page, you can see this example.

Using ADD in the Subject Index

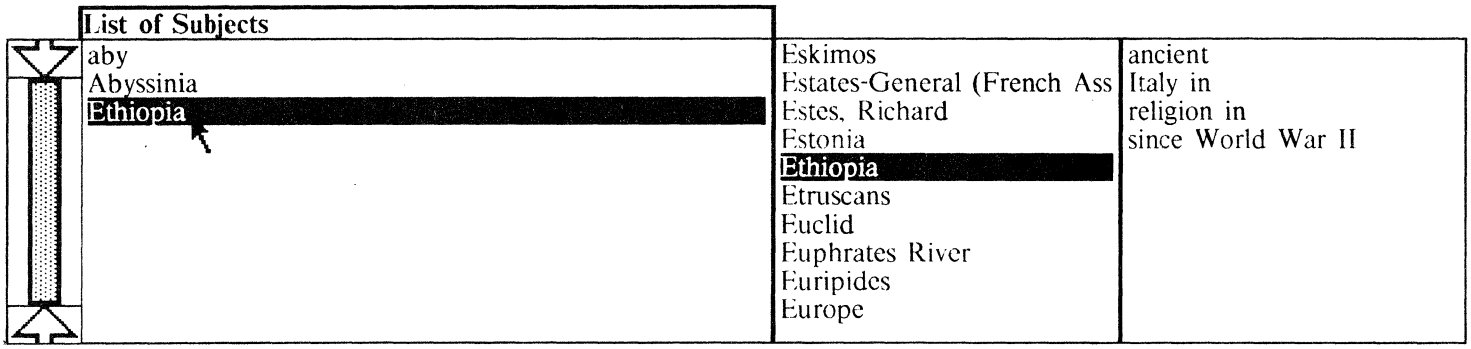
In the Figure below, "aby" was typed in the List of Subjects, and "Abyssinia" was selected in the Subject Index. Then, "Abyssinia" was added to the List of Subjects (by pressing the "ADD/MARK" button). Note the appearance of *Ethiopia* in the Sub-Subject Index.

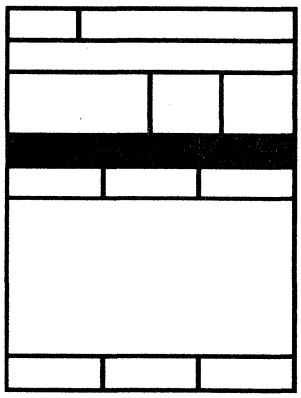


The next Figure shows the result of selecting "Ethiopia" in the Sub-Subject Index and adding it to the List of Subjects.



The last Figure shows the result of selecting "Ethiopia" in the List of Subjects.





List of Titles

In the conventional textbook, a subject refers you to a page number or a collection of page numbers. Another way to refer to this information is by a title, i.e., its chapter, section and sub-section. For example, the segments of the title "Early Civilizations in India>Indo-Aryans Build a Civilization>Vedic Age" correspond to the chapter Early Civilizations in India, the section in that chapter entitled Indo-Aryans Build a Civilization, and the sub-section with the heading Vedic Age. Compound titles contain embedded ">" rather than ":" as in compound subject terms.

Sometimes you can decide by looking at a title that it is or is not something that you want to examine further. Selecting a title causes the appropriate Chapter, Section, and Sub-Section to be selected, and text to be displayed in the Text Area.

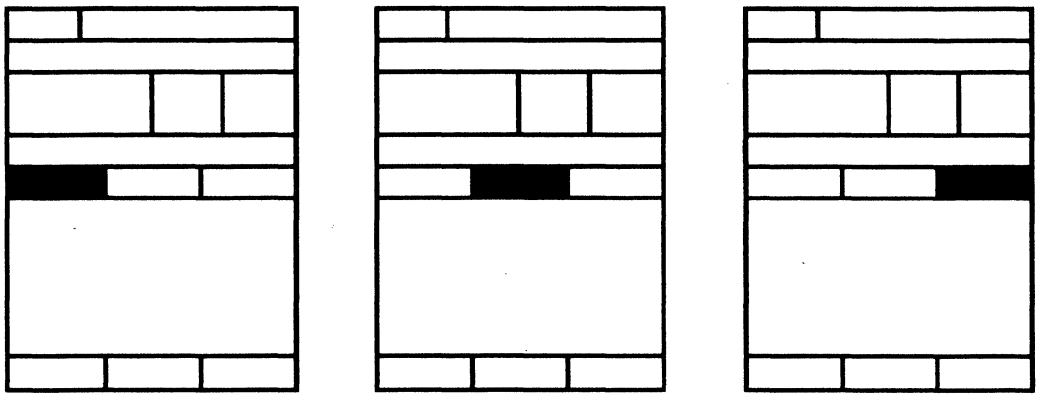
Typically, titles appear in the List of Titles as a result of selecting subject terms, or by adding titles from Chapters, Sections, Sub-Sections. A title with only two segments, e.g., Early Civilizations in India>Indo-Aryans Build a Civilization, would refer to the entire section. Similarly, a title with one segment would refer to an entire chapter.

Because selecting a subject in the Subject Index replaces the titles in the List of Titles, sometimes you'll lose a title that you wanted to refer to again. In order to save a title, press the "ADD/MARK" button on the mouse, and it will be marked -- this is somewhat similar to leaving a bookmark in the book at a particular page. It will not be deleted when a new subject is selected. In order to get rid of a marked title, select the "DELETE" button on the mouse.

A title in the List of Titles will often be abbreviated in order to fit, and may contain "..." at the ends of segments. Also, the segments both in the List of Titles and also the Title Index have been shortened even further by eliminating initial section numbers, and the words "the," "a," and "chapter."

Units appear in all UPPERCASE characters in Chapters. Typically, there's not much information associated with a Unit, and it is unlikely that a unit will be accessed very often in answering questions.

If a new title is the same as an older marked one, the old title will appear both bold and underlined. New entries will appear **bold**. Old marked entries will be just underlined.



Title Index: Chapters, Sections, Sub-Sections

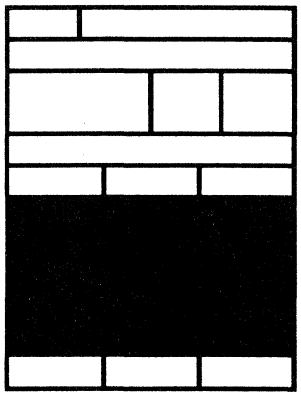
This is an expanded version of the table of contents that you would normally find at the beginning of the book. If you made a three level outline with chapters on the left, then major section headings, and finally smaller headings within sections, you would have an outline such as above.

Selecting a chapter will display the section names for that chapter in the Sections pane to the right, and some text in the Text Area, usually just the chapter heading. Selecting a section will display the corresponding sub-sections in the pane on its right, and some text in the Text Area, usually just the section heading, and some possible introductory material. Selecting a sub-section will display text in the Text Area.

You can add chapter, or chapter>section, or chapter>section>sub-section references to the List of Titles by pressing the "ADD/MARK" mouse button.

Selecting a chapter will display subject or compound subject terms that refer to the chapter as a whole in the Subject References (Chapter) pane; similarly, selecting a section will display subject references in the Subject References (Section) pane, and selecting a sub-section will display subject references in the Subject References (Sub-Section) pane. More about these later.

There is a slight ambiguity in the current way of referring to chapters and sections of the book. A title such as chapter>section could be interpreted to mean all of a section (i.e., the introductory material, and all of its parts), or just the introductory material presented when the section is selected. You should assume that such a title indicates that you should examine the entire section -- after inspecting some of the sub-sections, you might decide that you've found the information you were seeking.

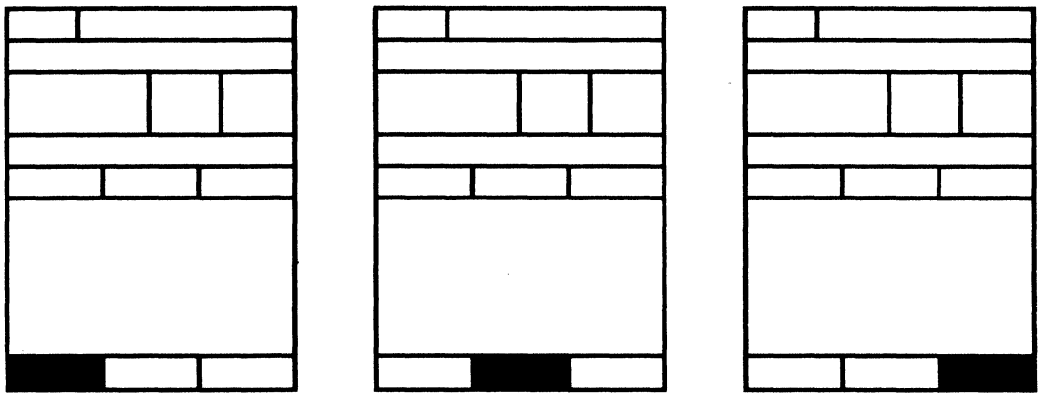


Text Area

This area displays a textual portion of the book. If all of the text is not visible, you can use the scrollbar on the left to move the text up.

Usually any words that exactly match the words selected in the Subject Index are emphasized or highlighted in **bold**. Certain common words such as "the" are not highlighted. Differences between UPPER and lower case characters are ignored. This, of course, will show you where people's names are mentioned and where specific subject phrases occur. However, it does exact matching of words, not phrases or word roots. This exact matching means that a word can be highlighted in different contexts (e.g., all uses of the word "king," not just "king" next to "arthur"). It also means that "war" as a subject term will not cause "wars" to be highlighted in the text, and vice versa.

Sometimes the text contains a reference such as "see page 000" -- you should ignore these.



Subject References

These panes contain *subject references* for each level of the book, corresponding to the selected chapter, section, and sub-section. These tell you what other subject terms in the Subject Index refer to the same chapter, or section, or sub-section. This is the inverse of the subject index, which contains titles for a given subject: for a given title, what are the subjects that refer to it. In the example figures earlier, the Subject References corresponding to the Sub-Section level contains "Archaeology" and "Artifacts, defined" in addition to "Culture, defined," which was our original subject term in the first example. If this sub-section seems relevant to you in looking for an answer to your question, these other subject references may refer not only to this same sub-section, but also to other related information. They are another form of "see also" which you have seen earlier in the Sub-Subject Index.

These *subject cross references* are displayed in *italics*, and when selected, can be added to the List of Subjects by pressing the "ADD/MARK" mouse button. They can then be selected in the List of Subjects to display the contents of that subject heading.

```
  ESC   1  2  3  4   5  6  7  8   9  0  -  =  \  LF  DEL
   TAB  Q  W  E  R  T  Y  U  I  O  P  [  ]  ←  BS
   CTRL  A  S  D  F  G  H  J  K  L  ;  '  RETURN
LOCK SHIFT Z  X  C  V  B  N  M  ,  .  /  SHIFT
```

Keyboard

You can type in the Answer pane, and the List of Subjects and Subject Index pane. BS (backspace) erases a single character. In the Answer pane, CTRL-W (hold down the CTRL key and type W) erases a single word; CTRL-X erases the entire answer. See List of Subjects for additional information about RETURN (to end typed subjects), "*" and "#" (in patterns), and DEL (to abort pattern searches).

Bold Face

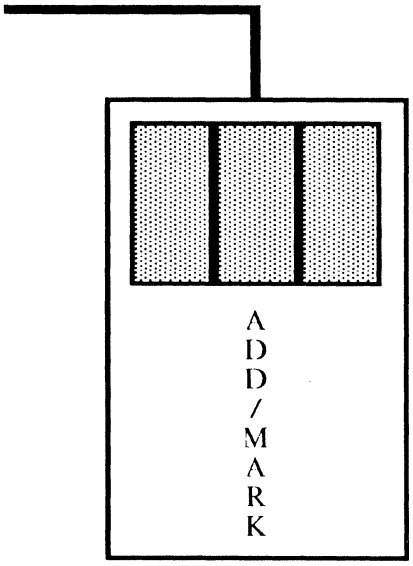
Bold face characters may be found in the List of Subjects pane to signify new subject terms, such as added subject cross references, or subjects found in a pattern search. New titles are displayed in bold in the List of Titles. Significant words from the current subject phrase are boldly displayed in the Text area. The question in the Question pane and the "next" command in the Command pane are displayed in bold. The titles of panes appear in bold.

Marked items

Subjects in the List of Subjects can be marked, i.e., made "permanent." Typically though, this is of main use in the List of Titles area for holding onto Title references that might otherwise disappear when you select a new subject.

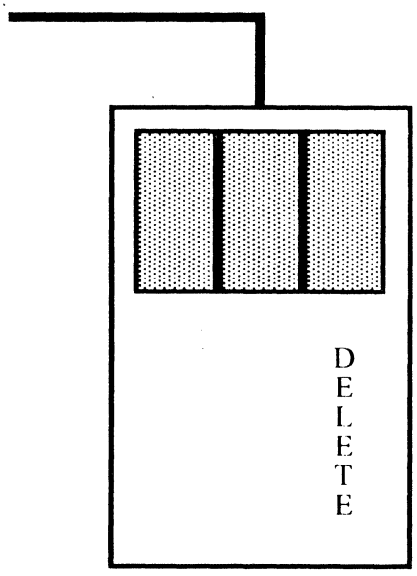
Subject cross references

These may appear as "see also" references in the Sub-Subject Index pane. They may also appear in the Subject References panes at the bottom of the Text area. Subject cross references are italicized and may be added to the List of Subjects.



ADD/MARK

The middle mouse button can be used to add the currently selected subject or compound subject from the Subject Index to the List of Subjects. Subjects in the List of Subjects can be marked. You can also add Title references from the Title Index to the List of Titles. Titles in the List of Titles can be marked.



DELETE

Use the rightmost mouse button to delete the current selection from the List of Subjects or List of Titles. Delete will get rid of both marked and unmarked entries.

Appendix D
Data Table and Latency Figures

Table D-1
Latency and Correctness Data for 16 Students on 20 Question Pairs

Student #	Question List	Book	Date (1981)
2	1	A	Thu May 28
	2	B	Fri May 29

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
latency																				
B	304	462	194	544	421	164	281	64	280	222	265	167	454	451	704	603	495	147	502	374
A	333	370	452	410	177	295	342	189	376	146	257	260	550	633	834	266	831	269	496	0
–	−29	92	−258	134	244	−131	−61	−125	−96	76	8	−93	−96	−182	−130	337	−336	−122	6	374
correctness																				
B	1.0	1.0	1.0	0.0	1.0	0.0	1.0	1.0	1.0	1.0	0.5	0.5	0.0	1.0	0.0	0.5	1.0	1.0	0.5	0.0
A	0.5	0.5	0.5	0.0	1.0	0.5	0.0	0.0	1.0	1.0	1.0	1.0	0.5	0.0	0.5	1.0	0.0	1.0	0.0	0.0
–	0.5	0.5	0.5	0.0	0.0	−0.5	1.0	1.0	0.0	0.0	−0.5	−0.5	−0.5	1.0	−0.5	−0.5	1.0	0.0	0.5	0.0

6	1	A	Fri May 15
	2	B	Sat May 16

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
latency																				
B	244	330	366	349	221	297	403	208	367	67	200	192	312	445	365	293	21	155	257	280
A	243	454	387	352	396	330	452	283	309	203	240	277	441	242	546	319	275	274	153	278
–	1	−124	−321	−3	−175	−33	−49	−75	58	−136	−40	−85	−129	203	−181	−626	−254	−119	104	2
correctness																				
B	0.5	0.5	1.0	0.0	0.0	1.0	0.0	0.0	1.0	1.0	1.0	1.0	0.5	1.0	0.0	0.5	0.0	1.0	0.0	0.0
A	1.0	1.0	0.0	0.0	1.0	0.0	1.0	0.0	1.0	1.0	1.0	1.0	1.0	0.0	1.0	1.0	0.0	1.0	0.0	1.0
–	−0.5	−0.5	1.0	0.0	−1.0	1.0	−1.0	0.0	0.0	0.0	0.0	0.0	−0.5	1.0	−1.0	−0.5	0.0	0.0	0.0	−1.0

10	2	A	Wed May 20
	1	B	Thu May 21

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
latency																				
B	255	509	539	395	165	450	213	380	414	99	244	562	279	410	695	377	554	155	535	180
A	490	651	557	446	492	333	427	421	343	105	425	384	381	558	744	447	175	0	0	0
–	−235	−142	−18	−51	−327	117	−214	−41	71	−6	−181	178	−102	−148	−49	−70	379	155	535	180
correctness																				
B	1.0	1.0	0.0	0.0	1.0	0.0	1.0	0.0	1.0	1.0	1.0	0.0	0.5	0.0	0.5	0.5	0.0	1.0	0.0	0.0
A	1.0	1.0	0.0	1.0	0.0	1.0	0.5	0.0	1.0	1.0	1.0	1.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
–	0.0	0.0	0.0	−1.0	1.0	−1.0	0.5	0.0	0.0	0.0	0.0	−1.0	0.5	−1.0	0.5	−0.5	0.0	1.0	0.0	0.0

15	2	A	Wed May 13
	1	B	Thu May 14

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
latency																				
B	248	226	261	569	168	467	625	314	272	98	119	394	470	352	579	507	510	224	321	401
A	323	259	480	390	169	235	383	197	570	279	416	306	383	510	499	256	269	489	382	125
–	−75	−33	−219	179	−1	232	242	117	−298	−181	−297	88	87	−158	80	251	241	−265	−61	276
correctness																				
B	1.0	1.0	1.0	0.0	1.0	0.0	0.5	0.0	0.5	1.0	0.5	1.0	0.5	0.0	0.5	0.5	0.5	1.0	0.5	0.0
A	0.0	0.5	0.0	1.0	0.0	1.0	0.0	1.0	1.0	1.0	0.5	1.0	0.0	0.5	0.0	0.0	0.0	1.0	0.0	0.0
–	1.0	0.5	1.0	−1.0	1.0	−1.0	0.5	−1.0	−0.5	0.0	0.0	0.0	0.5	−0.5	0.5	0.5	0.5	0.0	0.5	0.0

Table D-1 (continued)

Student #	Question List	Book	Date (1981)
4	1	B	Mon May 18
	2	A	Tue May 19

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
latency																				
B	311	316	788	625	485	171	415	524	256	120	361	125	347	793	243	388	427	105	430	132
A	325	575	210	440	571	234	208	148	348	78	203	258	424	837	404	238	314	305	384	172
–	−14	−259	578	185	−86	−63	207	376	−92	42	158	−133	−77	−44	−161	150	113	−200	46	−40
correctness																				
B	1.0	1.0	1.0	0.0	1.0	1.0	1.0	0.0	1.0	1.0	1.0	1.0	1.0	0.0	1.0	0.5	0.5	1.0	0.5	0.0
A	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.5	1.0	0.0	1.0	1.0	1.0
–	0.0	0.0	0.0	−1.0	0.0	0.0	0.0	−1.0	0.0	0.0	0.0	0.0	0.0	−1.0	0.0	−0.5	0.5	0.0	−0.5	−1.0

11	1	B	Fri May 15
	2	A	Sat May 16

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
latency																				
B	507	651	242	309	140	326	461	192	362	96	520	206	287	687	804	364	434	324	407	178
A	265	683	279	408	353	133	488	244	345	165	740	519	407	211	592	309	65	55	290	148
–	242	−32	−37	−99	−213	193	−27	−52	17	−69	−220	−313	−120	476	212	55	369	269	117	30
correctness																				
B	1.0	1.0	0.5	0.0	1.0	1.0	1.0	0.0	1.0	1.0	0.5	1.0	0.0	0.0	0.5	0.5	0.0	1.0	0.0	0.0
A	1.0	0.5	1.0	0.0	1.0	1.0	0.0	1.0	0.5	1.0	1.0	0.0	0.0	0.0	1.0	1.0	0.0	1.0	1.0	0.0
–	0.0	0.5	−0.5	0.0	0.0	0.0	1.0	−1.0	0.5	0.0	−0.5	1.0	0.0	0.0	−0.5	−0.5	0.0	0.0	−1.0	0.0

8	2	B	Wed May 20
	1	A	Th May 21

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
latency																				
B	404	1316	186	486	316	248	274	93	194	35	162	138	309	260	702	648	600	242	250	315
A	261	371	487	249	223	193	172	344	588	353	386	317	315	898	680	600	765	74	0	0
–	143	945	−301	237	93	55	102	−251	−394	−318	−224	−179	−6	−638	22	48	−165	168	250	315
correctness																				
B	1.0	0.5	1.0	1.0	1.0	1.0	1.0	1.0	0.5	1.0	1.0	1.0	0.0	1.0	0.5	0.5	0.5	1.0	1.0	1.0
A	1.0	0.5	1.0	0.5	1.0	1.0	1.0	0.0	1.0	1.0	0.5	1.0	0.5	1.0	0.5	0.0	0.5	0.0	0.0	0.0
–	0.0	0.0	0.0	0.5	0.0	0.0	0.0	1.0	−0.5	0.0	0.5	0.0	−0.5	0.0	0.0	0.5	0.0	1.0	1.0	1.0

14	2	B	Wed May 27
	1	A	Fri May 29

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
latency																				
B	262	363	321	232	490	239	678	75	327	91	244	520	326	528	556	337	307	63	740	464
A	206	260	169	313	201	222	741	440	181	111	364	336	327	298	399	381	548	125	344	306
–	56	103	152	−81	289	17	−63	−365	146	−20	−120	184	−1	230	157	−44	−241	−62	396	158
correctness																				
B	1.0	1.0	1.0	1.0	0.0	1.0	1.0	1.0	0.5	1.0	1.0	1.0	0.5	1.0	1.0	1.0	0.5	1.0	0.5	1.0
A	1.0	1.0	1.0	1.0	1.0	0.0	0.5	0.0	1.0	1.0	1.0	0.5	0.5	0.0	1.0	1.0	0.5	1.0	1.0	0.0
–	0.0	0.0	0.0	0.0	−1.0	1.0	0.5	1.0	−0.5	0.0	0.0	0.5	0.0	1.0	0.0	0.0	0.0	0.0	−0.5	1.0

Table D-1 (continued)

Student #	Question List	Book	Date (1981)
13	1	A	Fri May 22
	2	C	Sat May 23

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
latency																				
C	392	241	394	408	401	76	442	82	463	211	190	208	512	323	521	366	518	140	429	253
A	199	284	273	347	194	399	501	359	251	165	352	330	330	532	500	459	485	180	489	152
–	193	–43	121	61	207	–323	–59	–277	212	46	–162	–122	182	–209	21	–93	33	–40	–60	101
correctness																				
C	1.0	1.0	1.0	0.0	1.0	1.0	0.0	1.0	0.5	1.0	1.0	1.0	0.0	1.0	0.5	1.0	0.5	1.0	0.5	1.0
A	1.0	1.0	0.0	0.0	1.0	1.0	0.0	0.0	1.0	1.0	0.5	1.0	1.0	0.0	1.0	1.0	1.0	1.0	0.5	0.0
–	0.0	0.0	1.0	0.0	0.0	0.0	0.0	1.0	–0.5	0.0	1.0	0.0	–1.0	1.0	–0.5	0.0	–0.5	0.0	0.0	1.0

5	1	A	Mon May 4
	2	C	Tue May 5

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
latency																				
C	341	370	256	664	306	71	238	53	207	480	259	155	226	939	165	166	529	131	744	155
A	150	245	161	332	713	194	398	440	309	117	196	273	303	417	232	219	696	683	772	144
–	191	125	95	332	–407	–123	–160	–387	–102	363	63	–118	–77	522	–67	–753	–167	–552	–28	11
correctness																				
C	1.0	1.0	1.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	0.5	1.0	1.0	0.0	0.5	0.5	0.5	1.0	1.0	1.0
A	1.0	1.0	1.0	0.0	0.0	0.5	1.0	0.0	1.0	0.0	1.0	1.0	0.5	1.0	0.5	0.5	0.5	1.0	0.5	1.0
–	0.0	0.0	0.0	0.0	1.0	0.5	0.0	1.0	0.0	1.0	–0.5	0.0	0.5	–1.0	0.5	0.0	0.0	0.0	0.5	0.0

1	2	A	Mon May 25
	1	C	Tue May 26

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
latency																				
C	255	633	484	422	620	599	382	600	326	121	275	767	587	425	616	275	0	0	0	0
A	719	690	454	277	554	400	550	329	152	86	775	400	36	150	598	131	122	94	114	601
–	–464	–57	30	145	66	199	–168	271	174	35	–500	367	551	275	18	144	–122	–94	–114	–601
correctness																				
C	0.5	0.5	1.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	0.5	1.0	0.5	0.0	0.0	0.5	0.0	0.0	0.0	0.0
A	1.0	0.5	1.0	0.0	0.0	1.0	0.5	0.0	0.0	1.0	1.0	1.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	1.0
–	–0.5	0.0	0.0	0.0	0.0	–1.0	–0.5	0.0	1.0	0.0	–0.5	0.0	0.5	0.0	–1.0	0.5	0.0	0.0	0.0	–1.0

16	2	A	Wed May 6
	1	C	Thu May 7

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
latency																				
C	398	782	551	572	838	235	599	384	487	134	305	446	230	313	428	456	12	87	188	0
A	1020	1094	849	577	472	697	384	467	725	136	349	400	119	192	0	0	0	0	0	0
–	–622	–312	–298	–5	366	–462	215	–83	–238	–2	–44	46	111	121	428	456	12	87	188	0
correctness																				
C	0.5	0.5	0.0	0.0	0.0	1.0	0.5	0.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0
A	1.0	1.0	0.0	1.0	0.0	0.0	1.0	1.0	0.5	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
–	–0.5	–0.5	0.0	–1.0	0.0	1.0	–0.5	–1.0	0.5	0.0	1.0	1.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0

Table D-1 (continued)

Student #	Question List	Book	Date (1981)
3	1	C	Mon May 4
	2	A	Tue May 5

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
latency																				
C	229	319	144	670	176	262	468	656	238	139	145	275	266	686	537	393	507	109	627	159
A	250	441	136	280	416	88	188	121	376	52	416	200	426	170	383	315	728	75	693	232
–	-21	-122	8	390	-240	174	280	535	-138	87	-271	135	-160	516	154	78	-221	34	-66	-73
correctness																				
C	1.0	1.0	1.0	0.0	1.0	1.0	1.0	0.0	1.0	1.0	0.5	1.0	0.5	1.0	1.0	1.0	1.0	1.0	0.5	1.0
A	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
–	0.0	0.0	0.0	-1.0	0.0	0.0	0.0	-1.0	0.0	0.0	-0.5	0.0	-0.5	0.0	0.0	0.0	0.0	0.0	-0.5	0.0

9	1	C	Wed May 6
	2	A	Thu May 7

latency																				
C	177	485	256	807	678	425	641	295	171	158	260	335	557	532	528	482	434	229	55	0
A	210	558	228	493	272	169	609	260	409	89	443	303	554	558	469	496	725	146	248	190
–	-33	-73	28	314	406	256	32	35	-238	69	-183	32	3	-26	59	-14	-291	83	-193	-190
correctness																				
C	1.0	1.0	1.0	0.0	0.0	0.5	1.0	0.0	0.5	1.0	0.5	0.0	1.0	1.0	0.5	1.0	0.5	0.0	0.0	0.0
A	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.5	1.0	1.0	1.0	0.0	0.0
–	0.0	0.0	0.0	-1.0	-1.0	-0.5	0.0	-1.0	-0.5	0.0	-0.5	-1.0	0.0	1.0	0.0	0.0	-0.5	-1.0	0.0	0.0

7	2	C	Wed May 13
	1	A	Thu May 14

latency																				
C	576	185	177	126	442	372	600	90	283	79	168	763	231	674	842	345	290	289	437	188
A	260	220	164	164	394	72	470	406	509	81	198	267	229	163	339	371	935	150	277	162
–	316	-35	13	-38	48	300	130	-316	-226	-2	-30	496	2	511	503	-26	-645	139	160	26
correctness																				
C	0.5	1.0	1.0	1.0	1.0	0.0	0.5	1.0	1.0	1.0	0.5	0.5	0.0	0.5	0.5	1.0	0.5	0.0	0.5	1.0
A	0.5	1.0	1.0	0.0	0.0	0.0	0.5	0.0	1.0	1.0	0.5	0.0	0.5	0.0	0.5	0.5	1.0	0.0	0.5	0.0
–	0.0	0.0	0.0	1.0	1.0	0.0	0.0	1.0	0.0	0.0	0.0	0.5	-0.5	0.5	0.0	0.5	-0.5	0.0	0.0	1.0

12	2	C	Tue May 26
	1	A	Wed May 27

latency																				
C	420	426	447	492	358	242	288	460	268	381	406	472	337	214	356	283	318	182	454	128
A	233	538	480	187	551	274	418	297	487	225	275	285	220	336	384	342	372	493	303	564
–	187	-112	-33	305	-193	-32	-130	163	-219	156	131	187	117	-122	-28	-59	-54	-311	151	-436
correctness																				
C	0.5	1.0	1.0	0.0	0.0	0.5	1.0	1.0	1.0	0.0	1.0	1.0	0.5	0.0	0.0	1.0	0.5	0.0	0.0	0.0
A	1.0	0.5	0.0	0.0	0.0	0.0	1.0	0.0	0.5	1.0	0.0	0.5	1.0	0.0	0.5	0.5	0.0	1.0	0.5	1.0
–	-0.5	0.5	1.0	0.0	0.0	0.5	0.0	1.0	1.0	-1.0	1.0	0.5	-0.5	0.0	-0.5	0.5	0.5	-1.0	-0.5	-1.0

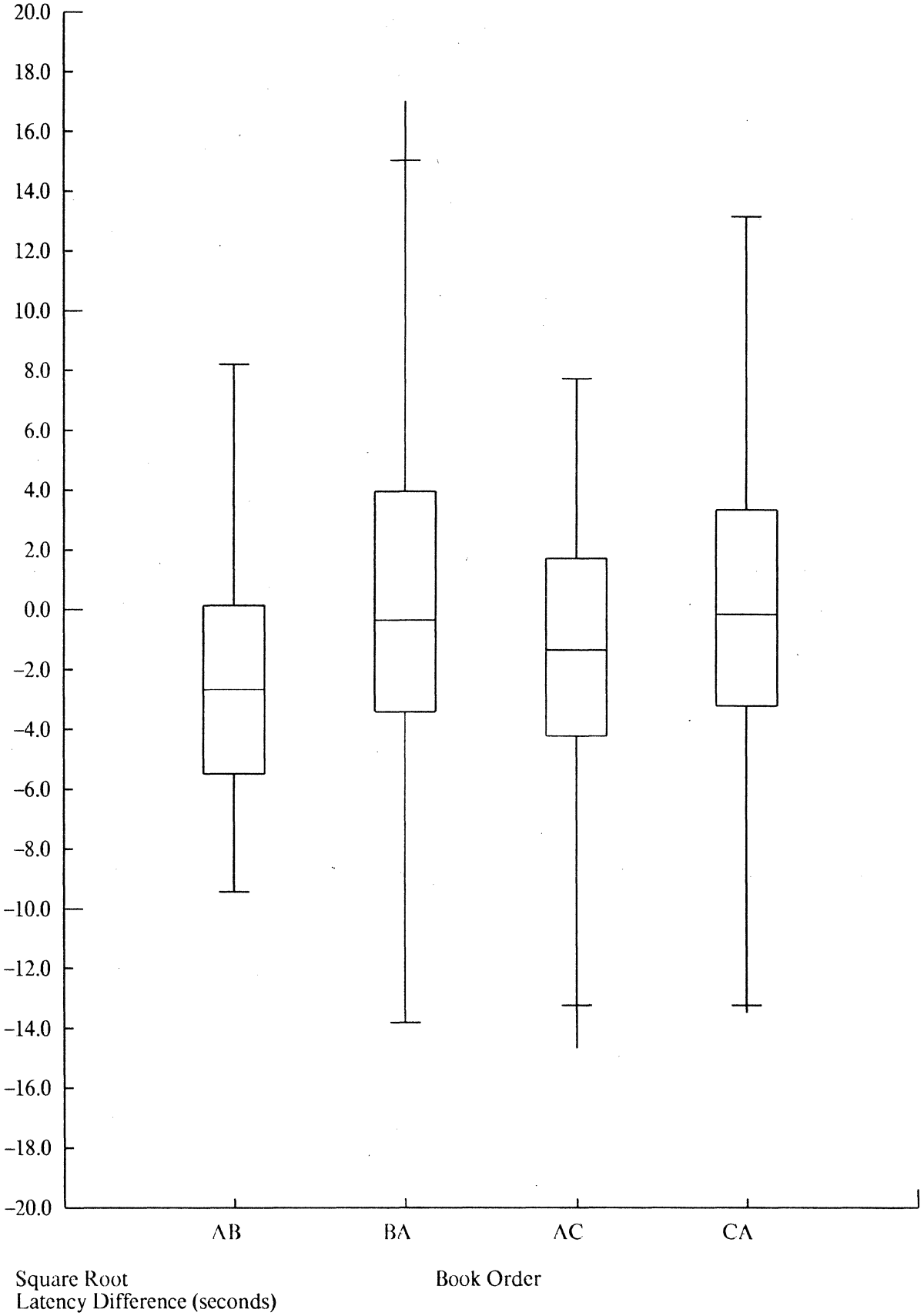


Figure D-1. Correct Only Square Root Latency Differences for All Students by Book Order

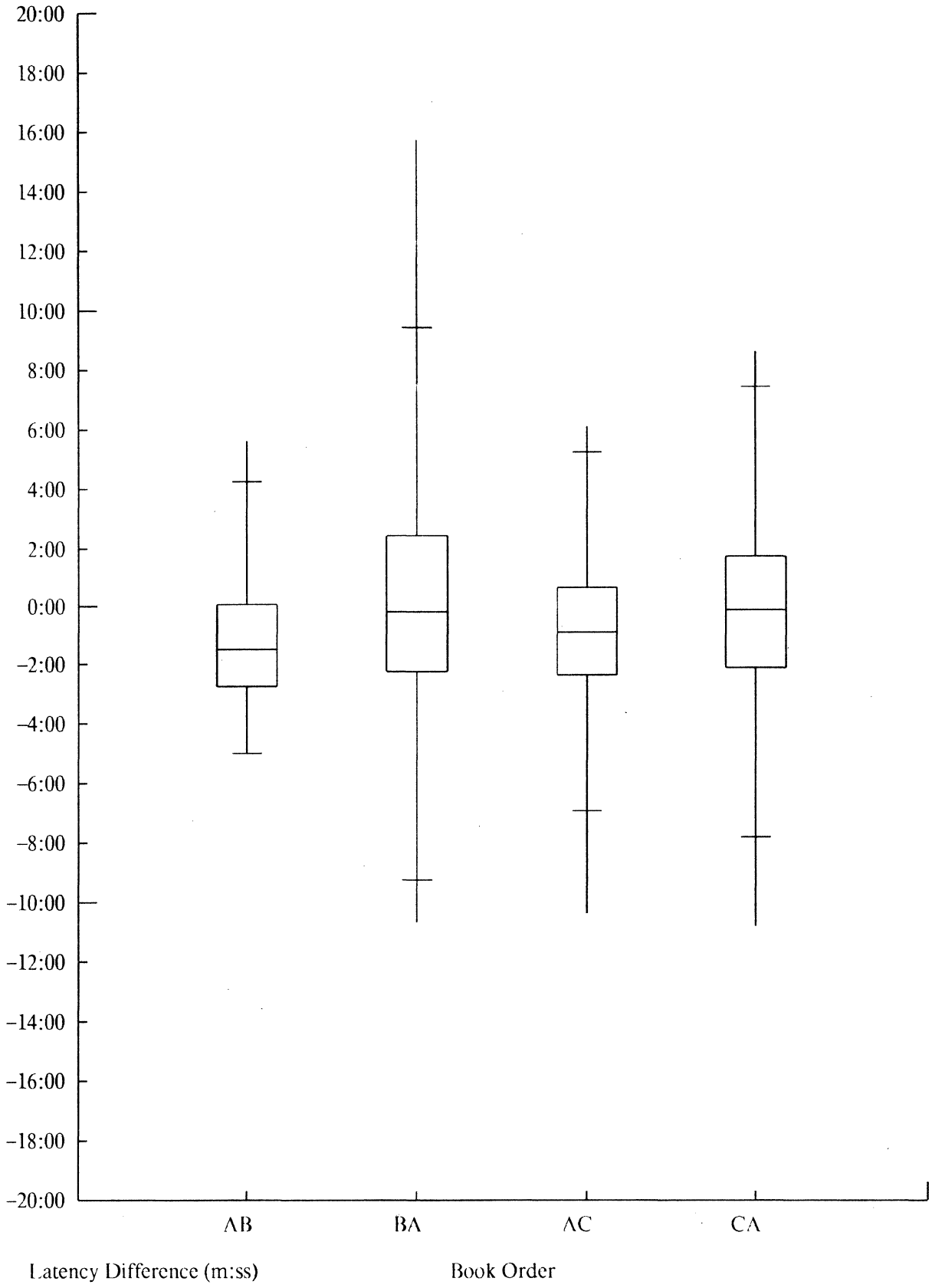


Figure D-2. Correct-Only Latency Differences for All Students by Book Order

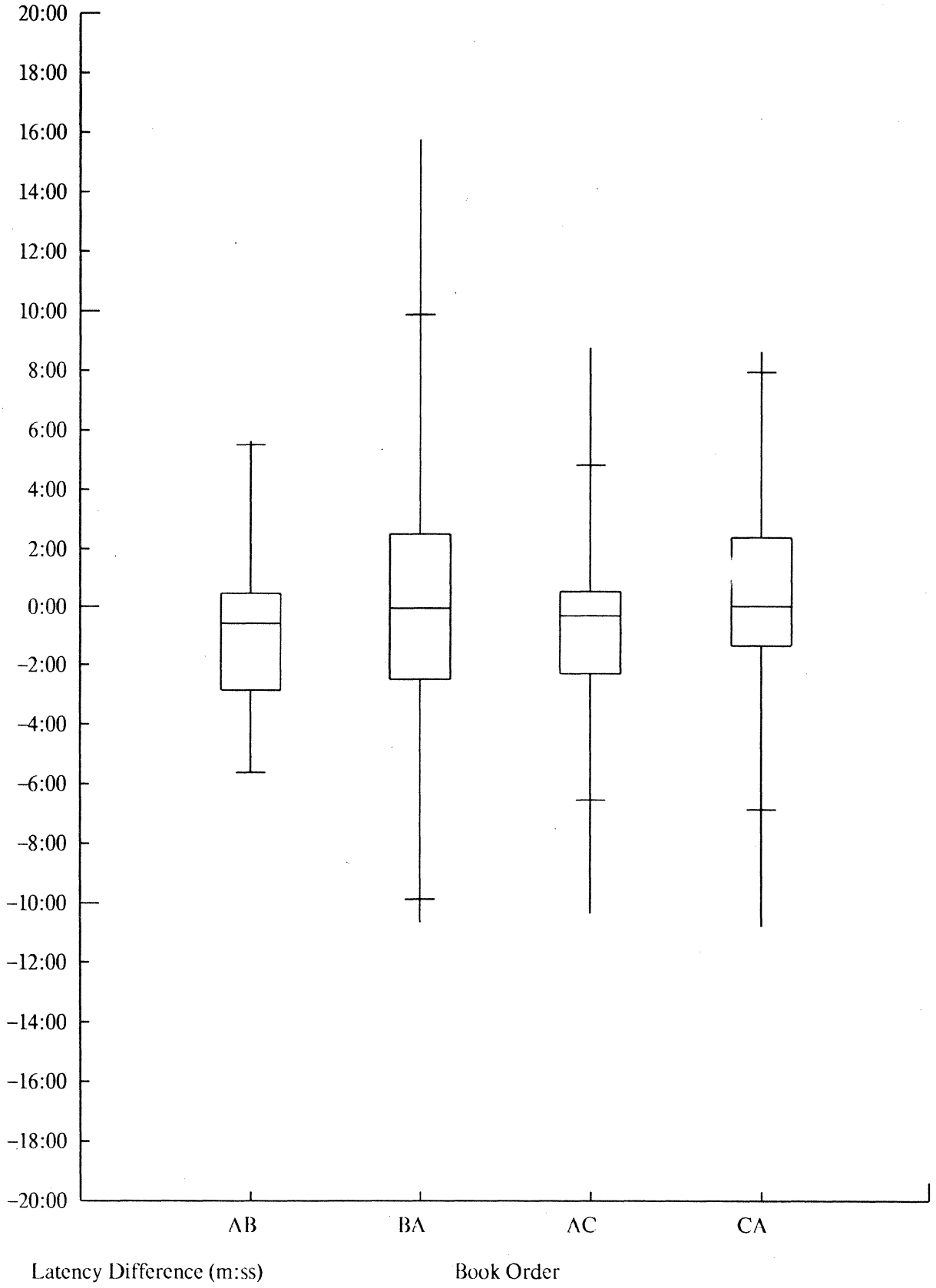


Figure D-3. Corrected (8 Min.) Latency Differences for All Students by Book Order

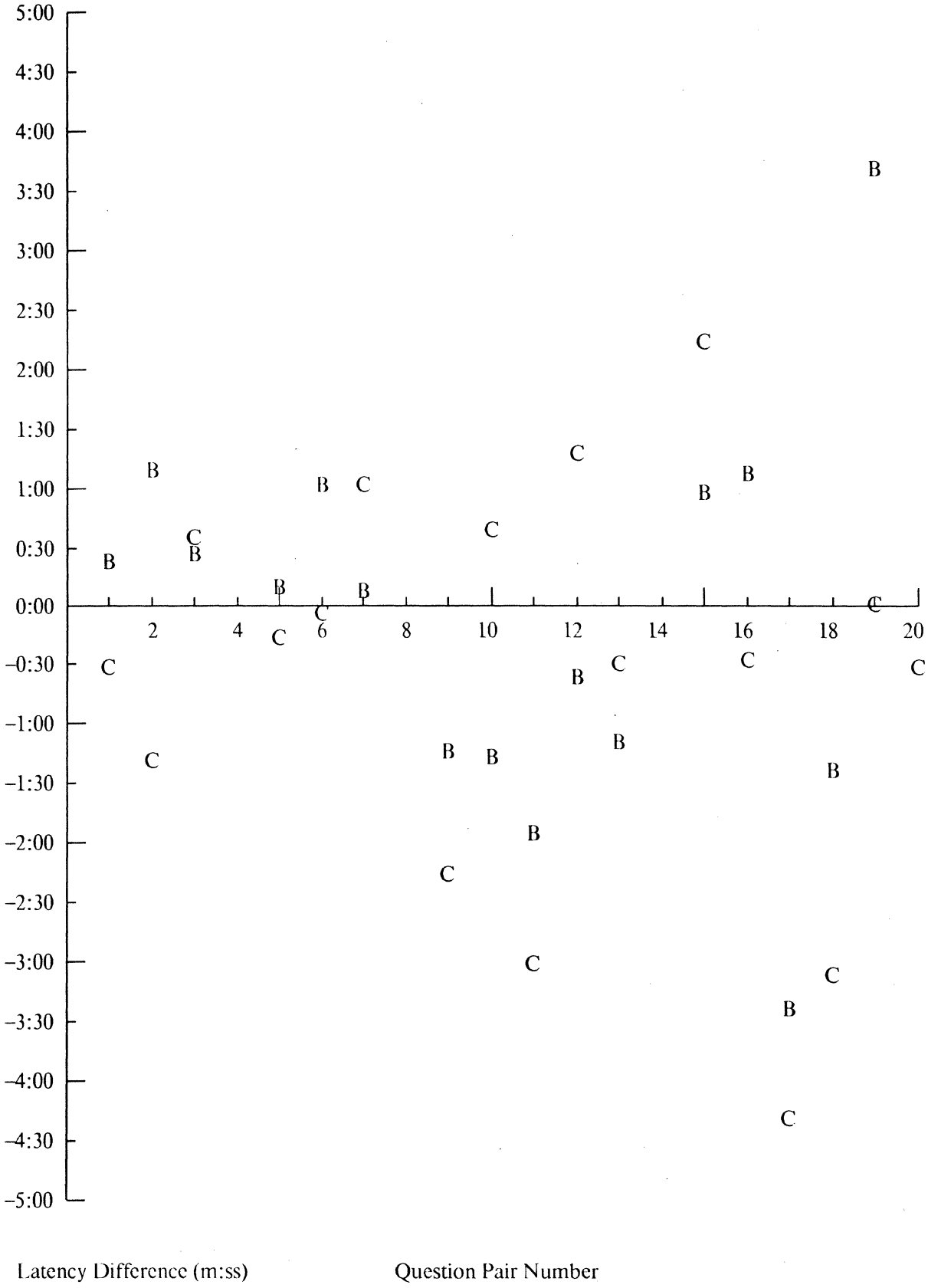


Figure D-4. Correct-Only Latency Differences for Book-B and Book-C Students by Question Pair

Appendix E

Index Examples

22 FOOD QUEST
- 221 Annual Cycle
- 222 Collecting
- 223 Fowling
- 224 Hunting and Trapping
- 225 Marine Hunting
- 226 Fishing
- 227 Fishing Gear
- 228 Marine Industries

23 ANIMAL HUSBANDRY
- ...

24 AGRICULTURE
- 241 Tillage
- 242 Agricultural Science
- 243 Cereal Agriculture
- 244 Vegetable Production
- 245 Arboriculture
- 246 Forage Crops
- 247 Floriculture
- 248 Textile Agriculture
- 249 Special Crops

25 FOOD PROCESSING
- ...

26 FOOD CONSUMPTION
- 261 Gratification and Control of Hunger
- 262 Diet
- 263 Condiments
- 264 Eating
- 265 Food Service Industries
- 266 Cannibalism

Figure E-1. Excerpt from Human Relations Area Files (Table of Contents) (Joyce, 1969)

Part Five. Human society

Division I. Culture

A. Cultural development

1. Cultures of primitive and non-urban societies

a. Cultures of hunters and gatherers: distribution and characteristics

i. Nomadic hunting and gathering societies

...

Part Nine. The history of mankind

Division I. Peoples and civilizations of ancient Southwest Asia, North Africa, and Europe

Section 911. Early peoples and civilizations of Southwest Asia and Egypt, the Aegean, and North Africa

A. Introduction: the character and achievements of ancient Near Eastern, Aegean, and North African civilizations; the geography of these regions; archaeological and documentary historical sources; historiographic problems

B. Mesopotamia and Iran to *c.* 1600 BC

1. Development of river valley civilization in Mesopotamia

...

c. The Sumerians from their origins to the end of the Early Dynastic Period (*c.* 2350 BC)

...

ii. Foundation of city states (*e.g.*, Kish, Ur, Uruk, Lagash, Mari, Umma); rivalry among the cities; the temple city and theocracy; social and economic organization; contacts with Egyptian and Indus Valley civilizations; Sumerian culture

articles	article sections	other references
MESOPOTAMIA	**11**:971d-972g	**1**:326c-e
AND IRAQ,	**11**:1002h-1003b	**11**:1061c-f
HISTORY OF	**18**:219d-e	**17**:797c
11:963-979	**18**:649e-h	**19**:521a-b
	...	

Figure E-2. Excerpts from the *Propaedia* of *Encyclopaedia Britannica* (Preece, 1979)

Prologue -- Prehistoric Peoples: Pioneers, Creators, Inventors

...

Unit 1. Civilizations Develop in Four Regions

Chapter 1. Interacting Civilizations in the Middle East

Keynote

A Birthplace of Civilization

Background to Cities and Civilizations

The Sumerians Develop Cities

Sumerian Religion and the Land

The Beginning of Writing

Many Specialists

A System of Trade

Social Structure

Government

Check on Your Reading

Newcomers Build Empires

Sargon I

Ur III and a Bureaucracy

...

Let's Meet the People! A Sumerian Schoolboy

Chapter Review

Think and Discuss

Past and Present

Activities

A Generation Gap 3500 B.C.: Using a Primary Source

Egyptian Civilization in the Nile Valley

...

Figure E-3. Excerpt from *Our Common Heritage* (Chapter, Section, Sub-Section Headings) (Roselle, 1981)

PHOTOGRAPHIC TRACKING
PHOTOGRAPHS
Photographs, Cloud
/ CLOUD PHOTOGRAPHS
Photographs, Lunar
/ LUNAR PHOTOGRAPHS
Photographs, Micro
/ MICROPHOTOGRAPHS
PHOTOGRAPHY

Figure E-4. Excerpt from *NASA Thesaurus* (Access Vocabulary)
(National Aeronautics and Space Administration, 1976)

PHOTOGRAPHS
GS PHOTOGRAPHS
. CLOUD PHOTOGRAPHS
. LUNAR PHOTOGRAPHS
. MICROPHOTOGRAPHS
. MOTION PICTURES
. PHOTOMICROGRAPHS
RT DISPLAY DEVICES
IMAGES
MOSAICS
OPTICAL CORRECTION PROCEDURE
...

Figure E-5. Excerpt from *NASA Thesaurus* (Alphabetical Listing)
(National Aeronautics and Space Administration, 1976)

Photographs
sa Aerial photographs
Painting from photographs
-- Albums
xx Albums
-- Cataloging
See Cataloging of pictures
-- Classification
See Classification -- Photographs
-- Coloring (TR485)
x Coloring of photographs
...
Photographs and painting
See Painting from photographs
Photographs in interior decoration (NK2115.5.P47)
xx Interior decoration
...
Photography (*Indirect*) (TR)
sa Ambrotype
Astronomical photography
Auroral photography
Calendar art
Calotype
Cameras
...
World War, 1939-1945 -- Photography
headings beginning with the word Photographic

Figure E-6. Excerpt from *Library of Congress Subject Headings* (Library of Congress, 1980)

photography

see also cinematography; colour photography; electrophotography; microphotography; photographic applications; photographic lenses; photographic materials; photographic process; radiography; streak photography

UF photographic techniques

NT cinematography
colour photography
microphotography
streak photography

RT cameras
colour
electrophotography
holography
optics
...
reproduction (copying)
schlieren systems

CC A0768 A8250 C3370N

FC a0768+r a8250-g c3370Nj

photography

+ **light sources**

UF photographic light sources

Figure E-7. Excerpt from *INSPEC Thesaurus* (Thesaurus)
(The Institution of Electrical Engineers, 1981)

photographic applications

. photogrammetry
. photolithography
. . masks
. . photoresists

photography

. cinematography
. colour photography
. microphotography
. streak photography

Figure E-8. Excerpt from *INSPEC Thesaurus* (Hierarchy)
(The Institution of Electrical Engineers, 1981)

PHOTOGRAPHS Jul. 1966
CIJE: 86 RIE: 117
BT Art Products
Films
RT Captions
Illustrations
Photography

PHOTOGRAPHY Jul. 1966
CIJE: 409 RIE: 235
SN Art of process of producing images on sensitized surfaces by the action of light or other radiant energy
BT Visual Arts
RT Film Study
Holography
Layout (Publications)
Microreproduction
Photocomposition
Photographic Equipment
Photographs
Reprography
Special Effects

Figure E-9. Excerpt from *Thesaurus of ERIC Descriptors* (Descriptors) (Educational Resources Information Center, 1977)

PHOTOGRAPHS
PHOTOGRAPHY
...
PHYSICS INSTRUCTUION
NUCLEAR PHYSICS
...
AUDITION (PHYSIOLOGY)
...
PILOT PROJECTS
AIRCRAFT PILOTS
PLACEMENT
ADVANCED PLACEMENT

Figure E-10. Excerpt from *Thesaurus of ERIC Descriptors* (Rotated ERIC Descriptor Display) (Educational Resources Information Center, 1977)

: : MASS MEDIA
: : : INSTRUCTIONAL MEDIA
: : AUDIOVISUAL AIDS
: FILMS
: : ART
: ART PRODUCTS
PHOTOGRAPHS

: : : : LIBERAL ARTS
: : : HUMANITIES
: : : ART
: : FINE ARTS
: VISUAL ARTS
PHOTOGRAPHY

Figure E-11. Excerpt from *Thesaurus of ERIC Descriptors* (Two-Way Hierarchical Term Display) (Educational Resources Information Center, 1977)

Appendix F
Questions, Answers, Subject Headings, and Comments

In the following pages, questions used in the experiment are briefly summarized. They are presented as pairs of questions -- corresponding, matched questions from the two question lists. An explanation of the general format used is outlined below:

Question: **list-question**
list indicates the question list number, 1 or 2.
question indicates the question number within the list, 1 to 20.

Answer:

This briefly summarizes the key points of an answer. Additional parts of an answer are prefaced with "also." Alternative answers are separated by commas or prefaced with "or." Answers with several parts or alternatives contain *Page*, *Title*, and *Subject Heading* attributes for each part or alternative.

Page(s):

This contains the page number(s) in the textbook where each part of an answer is found.

Title:

This parallels *Page* above by giving the heading of the part of the book that contains each part of the answer. Parts of these hierarchical titles are separated by ">", i.e., chapter>section>sub-section.

Subject Headings:

This is a list of subject terms that either refers to the exact page or part of the book, or (sometimes) to an adjacent part. Of course, it was also possible to find the correct sections by using subject terms that referred to parts further away, though this required more leafing through the book. Some of these were used by students and are included in "Other Subject Headings" below.

The terms listed here are followed by bracketed numbers to indicate the number of students who used this subject heading at least once. Because detailed protocol data was collected for only half the subjects on each question list, [8] is the maximum. It should not be too much of a surprise that some of the subject headings are not used at all, especially those that require advance knowledge of the answer or unnecessary generalization.

Other Subject Headings:

This summarizes some of the other successful and unsuccessful terms that students used, by either typing them in the Subject List or selecting them from the Subject Index. Some alphabetically adjacent subject headings were mistakenly selected; others were selected more than once; both these kinds of selections have been omitted.

"Egypt..., :science in [1]" indicates that Egypt and many of its sub-categories were selected, and that ":science in" was selected once.

For the most part, pilot students tried the same subject headings and made the same kinds of mistakes as did students in the later experiment. A few additional subject headings are included from the pilot data because they differed from those of the experiment. The frequencies on these occasional entries are suffixed with a "P" to indicate "Pilot", e.g., troops [1P].

Comment:

This evaluates the question success, question parallelism, and student errors. It appears after the second question of the question pair.

Question: **1-1.** Where did the Etruscans come from and whom did they conquer?

Answer: They came from Asia Minor and conquered Rome and other Latin towns.

Pages: 105-106

Title: Romans Build an Empire>Land and the People>Etruscans Conquer the Latins

Subject Headings:
Etruscans [8]
Italy:Etruscans [0]
Rome:under Etruscan rule [0]

Other Subject Headings:
migration etruscans [1]

Question: **2-1.** Where was the original home of the Bantu peoples? Name an area where they went.

Answer:
from -- Benue River Valley in Central Nigeria, tropical rainforests;
to -- East Africa and South Africa, Rift Valley, Indian Ocean, Zaire River, headwaters of Zambesi, much of African continent, savannas

Pages: 209-210

Title: Unity and Diversity: Peoples...>Great Migrations

Subject Headings:
Bantu:migrations of [5], :culture of [3], :kingdoms of [4]
Africa:migrations populating [0], :tribes of [0], :geography of [0]
Native Africans:Bantu [0]

Other Subject Headings:
bantu [1]

Comment: These questions were straightforward. Although *Bantu* had some sub-categories, all of them referred to the same general part of the book. There was more information about *Bantu* than about *Etruscans*, though much of it occurred after what would have been an adequate answer. The two subject pattern searches (involving * by students in Book C) were unnecessary, and students may have been simply experimenting. The subject index contains no subject headings for *Migrations*.

Question: **1-2.** What methods of writing were developed by the Phoenicians?
What methods of writing were developed by the Maya?

Answer: Phoenicians developed an alphabet (22 consonant sounds) and written words; also, Mayans used hieroglyphics

Page: 36

Title: Interacting Civilizations in ...>Phoenicians: Traders of the...>Alphabet

Subject Headings:
Writing:Phoenician [3]
Alphabet:Phoenician [0]
Phoenicians, the [5]

Page: 226

Title: Cultures and Civilizations of...>Civilizations of Middle America>Mayan Accomplishments

Subject Headings:
Writing:Maya [4]
Maya civilization [4]

Other Subject Headings:
Cuneiform [1]

Question: **2-2.** What methods of writing were developed by the Chinese?
What methods of writing were developed by the Inca?

Answer: Chinese -- ideograms, pictograms; also, Inca used quipu (knotted cords) or did not develop a system of writing

Page: 71

Title: Civilization Spreads from the...>China Has Had a Civilization...>Shang Civilization

Subject Headings:
Writing:Chinese [6]
Ideograms [0]
China:earliest civilization in [0]
Pictograms [0]

Page: 231

Title: Cultures and Civilizations of...>Inca Empire of Peru>System of Communication

Subject Headings:
Writing:Inca quipu [5]
Quipu (Incan form of communication) [0]
Inca, the [3]
Inca Empire [2]

Other Subject Headings:
China:culture of [3], :writing in [1]
Writing:Maya [1], :Aztec [1]

Comment: Both questions could be easily answered by looking under *Writing*, and selecting one of the sub-categories. When *Phoenicians* was selected, there was a sub-section in the text helpfully entitled *Alphabet*. *Cuneiform* (a student strategy) is mentioned as a possible basis for the Phoenician alphabet, but Cuneiform in the subject index does not refer to the Phoenicians. For *Maya*, one had to read the sub-section entitled *Mayan accomplishments*. For *Inca*, the sub-section about *System of Communication* contains something about their form of communication, though it wasn't really a form of writing. Students may have tried *Writing:Maya* and *Writing:Aztec* because of their geographical proximity to the Inca. For *China*, there are many further sub-subjects that could be selected. *Writing:Chinese* and *China:writing* do not refer to the same sections though. The latter refers only to the discussion of "oracle bones," which was a very limited kind of writing. The following section on *Shang Civilization* is also referred to by *Writing:Chinese*, and does contain the answer.

Question: **1-3.** What important effect did the Hundred Years' War have on French government?

Answer: strengthened king; growth of central government; unified nation

Page: 273

Title: Rise of Trade, Towns, and Nat...>Nations Develop>France Becomes a Unified Nation

Subject Headings:
Hundred Years' War [5]
France:Hundred Years' War and [2], :unification of [0], :medieval [0]

Other Subject Headings:
France [1]
French... [2], French government [1], French and Indian War [1], French Revolution [1]
government [1]
War of 1812 [1]
Wars...

Question: **2-3.** What effect did the Thirty Years' War have on the power of the Holy Roman Empire?

Answer: greatly weakened power of Holy Roman Empire;
Calvinism given equal status with Catholicism and Lutheranism; Switzerland independent

Page: 316

Title: European Nations Explore the ...>Power Struggle is Stepped...>Thirty Years' War (1618-1648)

Subject Headings:
Thirty Years' War [5]
Holy Roman Empire:in Thirty Years' War [3]
Religion:wars of [0]
Wars:Thirty Years' War [1]
Germany:and Thirty Years' War [0]

Other Subject Headings:
Roman Empire, the [4]
Holy [1]
thirty years' war [1], *years' war* [1], *war* [1]

Comment: For the first question, some students looked under different subject terms beginning with *French* for a long time before trying *France* or *Hundred Years' War*. In fact, one student evidently got confused and answered about the results of the French Revolution on French government. Although most wars appear in the subject index, both under its name and under the broader category *Wars*, *Wars:Hundred Years' War* was not present in the subject index.

For the second question, many students looked erroneously under *Roman Empire* rather than initially under *Holy Roman Empire*. None of the pattern searches were really necessary because *Holy Roman Empire* and *Thirty Years' War* were both present in the subject index. In the case of **thirty years' war**, the student aborted the search early.

Question: **1-4.** Describe an important change in warfare that occurred in Europe betwen 1450 and 1750.

Answer: cannons/artillery/firearms, mercenaries/professional soldiers, tactics, gunpowder, explosive shells, rifling, fragmentation shells; or standing army, shells

Page: 331

Title: Autocratic Rulers Contrast wi...>Rise of Prussia>Changes in Methods of Warfare

Subject Headings:
Armaments [0]
Gunpowder [0]
Mercenary troops [0]
Military:eighteenth century progress in [0]
Europe:culture of eighteenth century [2]

Page: 324

Title: Autocratic Rulers Contrast wi...>French Rulers Expand Their P...>Four Wars of Expansion

Subject Headings:
Alliances:seventeenth century [0]
Military:French [0]
France:in seventeenth century [0]
Wars:of the Palatinate [0], :Queen Anne's [0]

Other Subject Headings:
Warfare [2]
Europe..., :cooperative organizations of [2]
European ...
Wars [2]
change in warfare [1]
frontier [1]
1450 and 1750 [2]
1450 [1]
tactics [1P]
weapons [2P]
troops [1P]

Question: **2-4.** Name a weapon introduced to early Egypt about 1750 B.C.

Answer: horse-drawn chariots, body armor, better daggers&bows

Page: 43

Title: Egyptian Civilization in the ...>Egyptians Build a Civilization>Time of Disorder Was ...

Subject Headings:
Egypt:empire of [1], :Middle Kingdom of [1]
Hyksos, the [0]

Other Subject Headings:
Weapons:ancient Mesopotamian [5], :prehistoric [1]
weapons in Egypt [1]
Egypt:..., :science in [1]
1750 [1]
1750 [1]

Comment: Almost no students got the first question correct, and nine got the second question correct. Because of this mismatch, this pair was not included in the later analysis as described in Chapter 5. Both questions involved date ranges, and neither could be answered using information under the category *Weapons*.

For the first question, *Europe* would have been a useful subject category, if students had selected *Europe:culture in eighteenth century*. However, many students spent their time looking in other sub-categories, and at subject terms beginning with *European*, even when the time period was

obviously wrong, as with events involving World War II or the United Nations. Perhaps generating *Armaments* or *Military* from *warfare* or picking a country in Europe, such as France or Prussia, was too much to expect.

For the second question, the country was specific, and although there were no subject headings referring to weapons or military, it was easier to find the appropriate time period by selecting different sub-categories under *Egypt*. In other words, ancient Egypt was a smaller source to refer to and search than was medieval and modern Europe. Although *Weapons:ancient Mesopotamian* was selected by many students, it did not help in answering this question at all.

In neither case did dates or date searches succeed in the subject index because there was not a specific event such as *War of 1812*. However, a free-text search, if available, would have been successful in finding dates in the text itself.

Question: **1-5.** Name one way in which **Buddha** disagreed with the teachings of Hinduism.

Answer: opposed worship of gods and goddesses, and caste system

Page: 63

Title: Early Civilizations in India>Gautama and the Religion...>Prince Gautama and Buddhism

Subject Headings:
Buddha, Gautama [5]
Buddhism:in India [2]
Gautama, Siddhartha (Buddha) [1]
Religion:Buddhist in India [0], :in India [0]

Other Subject Headings:
Buddhism:beliefs of Mahayana [2]
Hinduism [3]
India:religion in [1]
Religion:Hindu [1]
teachings [1]

Question: **2-5.** Name one way in which the creation account of the Yakima is similar to the creation accounts of the Africans.

Answer:
supreme deity, peaceful time then break, following beliefs and teachings of ancestors

Page: 223

Title: Cultures and Civilizations of...>Some Varied Cultures of Nort...>Things in Common

Subject Headings:
Yakima tribe (Native American) [8]
Native Americans:religion of [0], :Yakima [0]
Religion:of Northern Native Americans [0]

Page: 207

Title: Unity and Diversity: Peoples...>Peoples and Kingdoms of West...>African Religions

Subject Headings:
Religion:African [1]
Africa:religions in [0]

Other Subject Headings:
Africa..., :earliest peoples of [6]
African...
creation [4]
early Africa [1]

Comment: The first question can be best answered by looking under *Buddha, Gautama. Buddhism* refers to Buddhist beliefs in Japan and elsewhere, and *Hinduism* refers to all Hindu beliefs. Students who looked only under these two latter subjects, typically came up with some differences between Buddhism and Hinduism, but not a reason why Buddha disagreed with Hindu teachings.

Most students easily found information about the Yakima in the second question, but had a harder time about the African creation account. Surprisingly, few students looked under *Religion:African* or *Africa:religions in.* The most successful strategy involved *Africa:earliest peoples of,* and then finding the sub-section *African Religions* later in the text. A free-text search for *creation* would also have yielded the correct sub-section.

Question: **1-6**. What architectural idea did the Romans probably borrow from the Egyptians? Where else did this idea appear over a thousand years later?

Answer: clerestory -- opening in walls that connects two roof levels to admit light to hall; cathedrals of western Europe

Page: 51

Title: Egyptian Civilization in the ...>Some Important Features of E...>Art and Architecture

Subject Headings:
Architecture:Egyptian [4]
Egypt:architecture of [2]

Other Subject Headings:
Roman Empire, the:architecture of [1]
Architecture:of Roman Empire [2]
Romanesque architecture and art [3]
Roman..., Roman Republic (of 1848) [1], Roman architecture [1]
early Roman architecture [1], Roman architectural ideas borrowed from Egyptians [1]
Rome [1]

Question: **2-6**. Name two architectural ideas that the Romans probably borrowed from the Etruscans.

Answer: arch, vault

Page: 106

Title: Romans Build an Empire>Land and the People>Etruscans Conquer the Latins

Subject Headings:
Architecture:Etruscan [2]
Etruscans [6]

Other Subject Headings:
Roman Empire, the:architecture of [4]
Architecture:of Roman Empire [0]
architect [1]
Romanesque architecture and art [1]

Comment: In both these questions, one may look first under the original inventor of the architectural idea, or under the later borrower. In the first question, clerestories are mentioned under Egyptian architecture, but not under Roman architecture. In the second question, arches and vaults are mentioned for the Etruscans, but only the arch is specifically mentioned under Roman architecture. Because Roman architecture is named, the subject index should probably refer to it, even in sections where the primary context is Egyptian or Etruscan.

Question: **1-7.** Who was king of England in 1215 and what significant democratic event occurred?

Answer: John (son of Henry II), Magna Carta (Great Charter)

Page: 269

Title: Rise of Trade, Towns, and Nat...>Nations Develop>Growth of Representative Government

Subject Headings:
Democracy:Britain [2], :Magna Carta [0]
Edward I, king of England [1]
John, king of England [1]
Magna Carta [0]
Parliament (English):the first [0]
Great Britain:in Middle Ages [0]
England:Normans conquer [1], :Hundred Years' War and [3]

Other Subject Headings:
king [2]
king of England [2]
1215 [2]
Democracy...
England..., :under Cromwell [3], :Christianity in [1], :and the Commonwealth [1]

Question: **2-7.** Who was king of England in 1628 and what significant democratic event occurred?

Answer: Charles I, Petition of Right

Page: 346

Title: Representative Government Gro...>Parliament Disputes the "Divine Right ...>Charles I ...

Subject Headings:
Democracy:Britain [0]
England:representative government in [3]
Parliament (English):strengthened [0]
Charles I, king of England [1]
Laws:Petition of Right [0]
Petition of Right [0]

Other Subject Headings:
1628 [2]
England..., :Hundred Years' War and [1], :under Cromwell [2]
king [5], *king of England* [1], * king * [1P]
George [1]
James [1]
Elizabeth [1P]

Comment: The second of these questions, and the first to some extent, are discussed at length in Chapter 5. It is tempting to look under dates to find the event, or to iterate through a list of kings. Unfortunately, the subject index does not have a list of significant dates or a *King* category. To remedy this latter problem, students guessed names of kings, e.g., *George*, or in Book C, generated a list of kings with the pattern **king of England** (a similar example was used in the training sequence). Students also selected subcategories under *Democracy* and *England*. "Significant democratic event" may have been a poor choice of words in the question, but it was not a problem for too many students.

For the first question, one student answered that Philip Augustus was king in 1215, but of the wrong country, France. Another student found the correct section, but answered Edward I who was mentioned later in the same section. In the second question, one student answered that Cardinal Richelieu (of France) captured La Rochelle in 1628.

Question: **1-8**. What was the first country to give women the same voting rights as men?

Answer: New Zealand

Page: 467

Title: Britain Strengthens Itself at...>Britain and New Zealand>New Zealand Introduces Adva...

Subject Headings:
Women:suffrage for [2]
Suffrage:for women [0]

Other Subject Headings:
Women..., :rights of modern [5], :in Japan, after World War II [1]
women's voting rights
vote, *voting rights*
Democracy
Amendments [2]
Equal rights
United States
Rights [2]
Election
President
American Constitution, American Revolution
Constitution

Question: **2-8**. In what year did women gain the right to vote in Japan?

Answer: 1947

Page: 581

Title: Asia Undergoes Great Changes>Democracy Develops in Japan>New Constitution

Subject Headings:
Women:in Japan, after World War II [3]
Japan:constitution for [3]
Suffrage:Japanese [0]

Other Subject Headings:
vote [3]
Women:in Japan [2], :in China [1]
Japan..., :and treaty of 1951 [2], :women in ancient [1]

Comment: Because these two questions were not equivalent in difficulty -- no students got the first one correct, and almost all students answered the second question correctly -- these questions were not included in the analysis. Finding the answer to the first question hinged almost entirely on using the term *Suffrage*, while in the second question, students could use some additional subject terms relating to *Japan*. Because many students selected *Women:rights of modern*, most of them also saw *Women:suffrage for* two lines later in the same list. It was not just a matter of not being able to recall the term, but also of not recognizing it. Three of the pilot subjects did answer the question correctly by looking under *Suffrage* or *Women:suffrage for*, so this question remained for the actual study. At least several students selected *Women:suffrage for* and the accompanying sub-section, but somehow missed reading the answer. Most students guessed the USA as the answer, although there was nothing in the text to support this. For students in Book C, the term *Suffrage* would have appeared in the Subject References area at the bottom of the screen if related information about voting in Britain or Japan were displayed, though there's no evidence that this helped. A free text search on *voting* would have yielded the correct sections for both questions. Perhaps *suffrage* is too technical or antiquated a term. At the very least, *voting* should have had a cross reference to it in the subject index, i.e., "see also Suffrage."

Question: **1-9**. Name two Romantic composers and one neo-Romantic composer.

Answer: Romantic: Beethoven, Mendelssohn, Wagner, Brahms, Chopin, ...; neo-Romantic: Rachmaninoff, Strauss

Page: 436

Title: Industrial Revolution Changes...>Industrial Revolution and th...>Romanticism in Music

Subject Headings:
Music:romantic [5]
Romanticism [4]
Beethoven, Ludwig van [0]

Page: 628

Title: Contemporary Changes and Futu...>Twentieth-Century Music Take...>Styles of Music

Subject Headings:
Music:neo-romantic [4]
Neo-romantic music [3]
Rachmaninoff, Sergei [0]

Other Subject Headings:
Music:twentieth century in [0]
composers [5]
romantic composers [3]

Question: **2-9**. Name an Italian Renaissance composer and two Baroque period composers.

Answer: Italian: da Palestrina or da Vinci; Baroque: Monteverdi, Lully, Bach, Handel, Haydn, Mozart

Page: 286

Title: New Ways of Thinking Change E...>Renaissance Flowers in Italy>Music

Subject Headings:
Music:Italian [4]
da Palestrina, Giovanni [0]
Madrigals [0]
Renaissance, the:music of [0]

Page: 278

Title: New Ways of Thinking Change E...>Keynote

Subject Headings:
Renaissance, the [1]

Pages: 338-339

Title: Autocratic Rulers Contrast wi...>Flowering of the Arts>Music in the Age of the Baroque

Subject Headings:
Music:Baroque [3]
Baroque music [4]
Bach, Johann Sebastian [0]

Other Subject Headings:
composers [2]
Renaissance, the:in Italy [2], :art of [1]
Italy:music of [1], :Renaissance in [1]

Comment: These were reasonably straightforward questions. It is interesting to note that students were about evenly divided whether they used subject terms such as *Music:Baroque* or *Baroque music*, i.e., looking up a subject first under its attribute (Baroque) or under its main concept (Music). Several students tried finding a list of composers. For the first question, one student answered with a Romantic painter and writer, but no composers. In the second question, several students answered with a composer who was Italian (e.g., Verdi, Lully), but not of the Renaissance period.

Question: **1-10**. Name an important tool that was probably invented by the Cro-Magnons.

Answer: burin, spear thrower; maybe also: knives, chisels, awls, scrapers

Pages: 10-11

Title: Prologue - Prehistoric People...>Cro-Magnon>Tools

Subject Headings:
Cro-Magnon humans [8]
Burin [0]
Prehistoric humans:tools of [0], :Cro-Magnon [0]
Technology:prehistoric [0]
Weapons:prehistoric [0]

Question: **2-10**. Name an invention that made navigation safer.

Answer: mariner's compass, rudder; or windrose compass, astrolabe

Page: 258

Title: Rise of Trade, Towns, and Nat...>Trade Expands and...>Rebirth of Large-Scale Trade

Subject Headings:
Navigation improvements [4]
Compass, mariner's [0]
Europe:medieval trade in [0]
Middle Ages:travel in [0], :trade in [0]
Trade:growth of after 1000A.D. [0]

Page: 302

Title: European Nations Explore the ...>Europeans Discover Other Par...>Prince Henry the ...

Subject Headings:
Navigation improvements [4]
Compass, mariner's [1]
Astrolabe [0]
Henry the Navigator [0]
Trade:colonial [0]
Exploration (European):begun by Portuguese [0]

Other Subject Headings:
inventions [1]
Navigation Act of 1651 (Britain) [2]

Comment: Neither of these questions presented a problem to students. In the first question though, many students stopped reading after the first paragraph and answered with general answers such as cutting tools and knives. Burin, the preferred answer, was mentioned in the second paragraph.

Question: **1-11.** When and where did farming probably begin in the Americas?
What became the most important grain crop?

Answer: Teohuacan valley, 7000 years ago, corn/maize; or northern Mexico, 5000 years ago, corn

Page: 217

Title: Cultures and Civilizations of...>People Spread Out Over the Americas>Beginning of Farming

Subject Headings:
Americas:farming in prehistoric [7]
North America:Native Americans of [0]

Page: 15

Title: Prologue - Prehistoric People...>Development of Farm Communities>Agriculture, Pottery, ...

Subject Headings:
Mexico:prehistoric agriculture in [0]
Native Americans:arrival of earliest [0]

Other Subject Headings:
Agriculture:prehistoric in [0], :the earliest [0], :nineteenth century changes in [1]
Americas:earliest peoples in [0]
Prehistoric humans:agriculture of [0], :farming by [0]
Farming [3]
crops [1], grain [1]

Question: **2-11.** Name two Native American tribes which did not adopt farming? On what did they depend for food?

Answer: Eskimo, Bella Coola, Chinook ate fish; some Great Plains Indians ate bison and buffalo

Page: 218

Title: Cultures and Civilizations of...>People Spread Out over the Americas>Some Were Not Far...

Subject Headings:
Agriculture:prehistoric in [0]
Eskimos [0]
Native Americans:Bella Coola [3], :Chinook [1]
Americas:farming in prehistoric [1], :Native Americans [2]
North America:Native Americans of [0]
Pacific Northwest [0]

Page: 223

Title: Cultures and Civilizations of...>Some Varied Cultures of North...>Great Plains

Subject Headings:
Native Americans:of the Great Plains [0]

Other Subject Headings:
Native Americans..., :arrival of earliest [2]
Americas:earliest peoples in [1]
Farming [1]
tribes [1]
Indians [1P]

Comment: In both questions, *Farming* is used. This subject index term does not refer to the text -- students are immediately referred to the related term *Agriculture*. The first question was a little easier than the second because the subject term *Americas* could be used. The beginning of farming implies an early period in history, though one student did select *Agriculture:nineteenth century changes in*.

The second question can also be answered using the category *Agriculture:prehistoric* though none did so. *Native Americans* as a subject does not contain *agriculture* or *farming* as convenient sub-categories, instead it mainly lists the names of tribes. Fortunately, the first tribe, Bella Coola, refers to a sub-section entitled *Some Were Not Farmers* in which a suitable answer can be found.

Question: **1-12.** Give two reasons for exploration by Europeans in the latter 15th and early 16th centuries.

Answer: capitalism (profit), desire for gold, spices, competition for trade, adventure, religion

Page: 306

Title: European Nations Explore the ...>Causes and Effects

Subject Headings:
Exploration (European):reasons for [6], :begun by Portuguese [2]
Trade:colonial [0], :as reason for exploration [0]
Colonies:Portuguese [0]
Religion:as a reason for exploration [0]

Other Subject Headings:
Europe...
early 15th centuries [1]
economic developments [1]
European Recovery Program (ERP) [2]
European exploration...

Question: **2-12.** What two effects did the French Revolution have outside of France?

Answer: growth of democracy, development of nationalism, rulers feared spread of revolution

Page: 376

Title: French Revolution and Napoleo...>French Revolution>Results of the French Revolution

Subject Headings:
French Revolution:results of [7]
Nationalism:stimulated by French Revolution [0]
Revolutions:French [0]
Democracy:in France [0]
France:revolution in [1]

Other Subject Headings:
French Revolution...

Comment: These two questions are similar in that much information is available about *Exploration*, and about the *French Revolution*, but there are also sub-categories in the subject index *Exploration (European):reasons for* and *French Revolution:results of* that conveniently refer to smaller amounts of information.

Question: **1-13.** Name two features of feudalism that were the same in China, Japan and Europe.

Answer: personal bond between lord and vassal -- loyalty;
contract -- land/fief and protection in exchange for services -- taxes, military

Page: 70

Title: Civilization Spreads from the...>Chou Dynasty>Government

Subject Headings:
Feudalism:Chinese [8]
China:feudalism in [0]

Pages: 242-243

Title: Christianity and Feudalism in...>People of Europe Seek Safety from New Invaders

Subject Headings:
Feudalism:European [7], :the contract in [0]
Fiefs [0]
Oath of fealty [0]
Vassal [0]

Page: 193

Title: Japanese Build a Civilization>Feudalism Emerges in Japan>Samurai Serve as Feudal Warriors

Subject Headings:
Feudalism:Japanese [8]
Japan:feudalism in [1]

Question: **2-13.** Name two results of large scale irrigation which were similar in Mesopotamia, Egypt, and the Aztec empire.

Answer: large population, cities, civilization, grow every season, reduce chances of a famine

Page: 40

Title: Egyptian Civilization in the ...>Egyptians Build a Civilization>Unified Government is ...

Subject Headings:
Irrigation:Egyptian [7]
Egypt:irrigation in [1]
Civilization:features [0]

Pages: 23-24

Title: Interacting Civilizations in ...>Birthplace of Civilization>Background to Cities and ...

Subject Headings:
Irrigation:in Mesopotamia [7]
Tigris River [0]
Technology:in Mesopotamia [0]
Mesopotamia:early civilization in [1]

Page: 228

Title: Cultures and Civilizations of...>Aztec Empire>Aztec Capital, Tenochtitlan

Subject Headings:
Irrigation:Aztec [7]
Mexico:early cultures of [0], :Aztec in [0]
Aztecs [2]

Comment: These two questions are similar in that they ask for a comparison between three countries or empires with respect to feudalism (in the first question) and irrigation (in the second). Both can be most simply answered by using the subject terms *Feudalism* and *Irrigation* and selecting the proper sub-categories for each geographical area. For the second question, some students answered with some features of irrigation rather than results.

Question: **1-14.** What three legislative acts in Germany provided protection similar to that of Britain's National Insurance and Assistance program?

Answer: Sickness Insurance Act, Accident Insurance Act, Old Age and Incapacity Act

Page: 575

Title: Power Struggles and a Search ...>Events in Other European Cou...>Great Britain Adopts ...

Subject Headings:
National Insurance and Assistance (Britain) [1]
Great Britain:social welfare [0]
Social Welfare:in Britain [0]

Page: 456

Title: Italy and Germany Form Nations>Independent Germany From 1871 ...>Social Welfare

Subject Headings:
Social Welfare:in Germany [0]
Germany:social welfare [3]
Socialism:in Germany [0]

Other Subject Headings:
German..., Germany...
medical [1]
insurance [2]
protection [3]
acts [3]
Britain, British..., Great Britain...
legislation [3]
legislative acts in Germany [1]

Question: **2-14.** What event in France was similar to the Education Act of 1870 in England? In what year did that occur in France?

Answer: Napoleon established public schools in 1813;
or establishment of national system of public education in 1880

Pages: 429-430

Title: Industrial Revolution Changes...>Industrial Revolution and Re...>Reform of Education

Subject Headings:
Education:Education Act of 1870 [6], :compulsory[0]

Page: 379

Title: French Revolution and Napoleo...>Napoleonic Program in France>Reorganization of Educ...

Subject Headings:
Education:French [5]

Pages: 406

Title: Revolutions Challenge Autocra...>Third Republic

Subject Headings:
Education:French [3]

Other Subject Headings:
education act of 1870 [4]
1870 [2]
France..., :literature in [1]
1870 [1]
act [1]
England...

Comment: Both of these questions are forms of analogy: A is to B, as C is to ? One strategy would be to determine what is unique about the Education Act of 1870 or about the National Insurance and Assistance program, and then to look for a similar law or program in the other country. One could take a chance and skip this first part, and guess that the Education Act of 1870 involved establishing schools, and that the National Insurance and Assistance program involved social welfare (as one student did). For the first question, though, one student answered "Triple alliance", and another answered with three changes to English Parliament; again a possible example of an answer satisfying some of the attributes (i.e., three things) being better than none. For the second question, many students stopped prematurely after reading the first of two references about French education. Of course, it all depends on your definition of "similar;" perhaps the second reference about compulsory education would have been a better answer. Unfortunately, **1870** did not work for finding *Education:Education Act of 1870* because the match works only for the first parts of compound subject terms (although it could be made to work for sub-subjects (*Education Act of 1870*) as well).

Question: **1-15**. What probably started the War of the Spanish Succession? What was this war called in North America and which two countries fought there? Which treaty ended the war?

Answer: England and Austria were determined not to allow the crowns of Spain and France to be united; Queen Anne's War; France and England fought there; Treaties of Utrecht.

Page: 324

Title: Autocratic Rulers Contrast wi...>French Rulers Expand Their P...>Four Wars of Expansion

Subject Headings:
Spanish Succession, War of the [4]
North America:French and English wars in [0]
Queen Anne's War [1]
Treaties:Utrecht [0]
Utrecht, treaties of [0]
War of the Spanish Succession [4]
Wars:Queen Anne's [0], :of the Spanish Succession [0]

Page: 360

Title: England Wins an Empire and Lo...>English Take French Lands>Queen Anne's War

Subject Headings:
Queen Anne's War [1]
Treaties:Utrecht [0]
Utrecht, treaties of [0]
War of the Spanish Succession [4]
Wars:Queen Anne's [0], :of the Spanish Succession [0]

Question: **2-15**. What probably started the Seven Years' War? What was this war called in North America and which two countries fought there? Which treaty ended the war?

Answer: revenge against Prussia; French and Indian War; France and England; Peace of Paris

Page: 326

Title: Autocratic Rulers Contrast wi...>Growth of the Austrian Empire>Maria Theresa Becomes ...

Subject Headings:
Seven Years' War, the [2]
England:in Seven Years' War [0]
France:in Seven Years' War [1]
Maria Theresa, queen of Austria [0]
Wars:Seven Years' [0]

Page: 360

Title: England Wins an Empire and Lo...>English Take French Lands>French and Indian War

Subject Headings:
Seven Years' War, the:in North America [7]
Wars:Seven Years' [0], :French and Indian [0]
French and Indian War [0]
Peace of Paris [0]
Treaties:Paris, Peace of [1]
North America:English colonies in [0]

Other Subject Headings:
War of 1812 [1]
Queen Anne's War [1]
North America:French and English wars in [1]
Seven Years' War, the:France and [3]

Comment: The answer to the first question requires two different sections of the book. Unfortunately, the subject entry *Spanish Succession, War of the* refers to only the first of these, while *War of the Spanish Succession* and *Wars:of the Spanish Succession* refer to both. There is no reason for these to be different except for carelessness on the part of the indexer.

The answer to the second question also requires two parts. Because the Seven Years' War is mentioned in more than these two places, there are some additional subject sub-categories that complicate the finding of the information. As was also the case with the first question of this pair, careless reading of some of the text often resulted in mixups between various wars and treaties; for example the War of the Palatinate preceded the discussion of War of the Spanish Succession, and War of the Austrian Succession was often confused with the Seven Years' War.

Question: **1-16.** Name the three major rivers of China. Along which river did Chinese civilization first develop? Where was the Great Wall built?

Answer: Yellow, Yangtze, West
civilization -- on Yellow;
Great Wall -- north of China where it's open to invaders, south of Mongolia;
or Kansu eastward for 1400 mi. to Pacific ocean

Page: 67

Title: Civilization Spreads from the...>Lands of the Middle Kingdom

Page: 74

Title: Civilization Spreads from the...>First Chinese Empire...>Shih Huang Ti Rules China

Subject Headings:
China [1], :geography of [3], :earliest civilization in [2]
Great Wall of China [3]
Yellow River [0]
West River [0]
Yangtze River [0]

Other Subject Headings:
China:tributary system [2]
rivers [4], *river* [1]

Question: **2-16.** Name the two major rivers of India. Along which river did Indian civilization first develop? During which months of the year does the monsoon season occur?

Answer: Indus, Ganges; Indus; June-Sept

Pages: 55-56

Titles: Early Civilizations in India>Varied Lands and Climates of a Subcontinent
Early Civilizations in India>Ancient Civilization of the Indus River Valley

Subject Headings:
India:geography of [5], :climate of [1], :earliest culture in [3]
Ganges river [1]
Indus river [2]
Monsoon [4]

Other Subject Headings:
rivers [2]
Civilization:earliest [1]
India...

Comment: Both questions could be answered by selecting *China:geography of* or *India:geography of* and reading several adjacent sections. Students often skipped these when initially scrolling through the sub-categories, perhaps looking for *China:rivers of*, for example. The term *China:tributary system of* seems reasonable but "tributaries" is misleading; it refers to the custom of local rulers sending tribute, i.e., gifts, to the emperor. Because geography was discussed near the beginning of the chapter, any subject term that referred to the beginning of that civilization would also suffice. *Great Wall of China* and *Monsoon* also referred to sections adjacent to those on geography, and the intent was that students would find this information from answering the first part of the question, and not by accessing the subject index a second time. The pattern **river** would be successful except that the three Chinese rivers are near the end of the alphabet, and many other irrelevant rivers occur first if one selects them in that order.

Question: **1-17**. Briefly summarize and compare the concept of human equality that is presented in the Code of Hammurapi, the Roman Twelve Tables, the Code Napoleon, and the Hindu religion.

Answer: Hammurapi -- unequal punishment for citizens and slaves;
Napoleon --- equality of citizens before law;
Twelve Tables -- unequal punishment; Hinduism -- caste system unequal

Page: 30

Title: Interacting Civilizations in ...>Newcomers Build Empires>Code of Laws

Subject Headings:
Laws:Code of Hammurapi [0]
Code of Hammurapi [4]
Hammurapi, king of Babylonia [2]

Page: 379

Title: French Revolution and Napoleo...>Napoleonic Program in France>Code Napoleon

Subject Headings:
Laws:Code Napoleon
Code Napoleon [5]
Napoleon I (Bonaparte):law under [0], :economy under [1]

Page: 107

Title: Romans Build an Empire>Roman Republic Develops>Plebians Win the Struggle for a ...

Subject Headings:
Laws:in Roman Empire [0]
Twelve Tables (Roman law) [3]

Page: 61

Title: Early Civilizations in India>Indo-Aryans Build a Civilization>Caste System Develops

Subject Headings:
Hinduism [6]
Religion:Hindu [1]
Caste system (India) [0]
India:caste system [0]

Other Subject Headings:
Roman twelve tables [2]
Roman Empire, the:law of [1]
Roman Republic (of 1848) [2]
Roman Question, the [1]

Question: **2-17**. Briefly summarize and compare the educational opportunities for women that were available in Greece, during the Epic Age of India, in the Roman Republic, and during the Renaissance.

Answer: Greece -- no education outside home (though Aspasia and well-to-do were exceptions);
India -- women could become scholars in Vedic Age, though in Epic age, only a few well-to-do were given an education;
Roman Republic -- girls trained by mothers at home; Renaissance -- upper class women had tutors

Page: 88-89

Title: Greeks Build a Western Civili...>City-State: a Greek's "Coun...>Women in Greek Life

Subject Headings:
Women:in Greece [1]
Education:Greek [6]
Greece:women in [1]

Pages: 61-62

Title: Early Civilizations in India>Indo-Aryans Build a Civilization>Position of Women

Subject Headings:
Women:in India [1]
India:Epic Age in [0], :women in [1]

Page: 286

Title: New Ways of Thinking Change E...>Renaissance Flowers in Italy>Women of the Renaissance

Subject Headings:
Women:of the Renaissance [1]
Renaissance, the:women of [0], :education in [3]

Page: 117

Title: Romans Build an Empire>Lives of the Romans>Roman Education

Subject Headings:
Women:in Roman Republic [1]
Education:in Roman Republic [3]
Roman Empire, the:education in [0]

Other *Subject Headings*:
Education..., :in India [3]
India:education in [1]
Italy:education in [1]
Epic Age (India) [1]
Roman Republic (of 1848) [1]

Comment: The first question required four legal or religious sytems to be compared. Some students skipped this one if they did not have much time left, evidently because they thought it was difficult. *Roman twelve tables* was not a subject heading, and *Roman Republic (of 1848)* put students into the wrong time period. *Roman Empire, the:law of* and *Laws:in Roman Empire* do not refer to all of the same parts of the book.

Women was a better subject category to use than *Education*, because *Education* usually referred to educational systems that did not include women (though, of course, students didn't know that initially).

Question: **1-18.** After which Chinese dynasty did foreigners begin using the name "China"?

Answer: Ch'in

Page: 74

Title: Civilization Spreads from the...>First Chinese Empire Is Established

Subject Headings:
China [1], :Ch'in dynasty [3], :earliest civilization in [1]
Ch'in dynasty, China [0

Other Subject Headings:
China:Ching dynasty, :Chou dynasty, :Han dynasty
Chinese dynasty [1]

Question: **2-18.** What is the origin of the name "England"?

Answer: Land of Angles

Page: 237

Title: Christianity and Feudalism in...>Church Provides Strength and...>Angles and the Saxons in ...

Subject Headings:
England:source of name [7]
Angles [0]
Great Britain:Anglo-Saxon invasion of [0], :language of [0]
Language:English in [0]

Other Subject Headings:
origin [2]
name [1]
England..., :American colonies and [2], :Renaissance in [1]

Comment: The first question is best answered by looking at the China subcategories that name dynasties -- Ch'in is the first of these. One possible confusion was a section mentioning *Chung Kuo*, after which the Chinese themselves named their country. The second question is best answered by looking at the convenient *:source of name* subcategory under *England* -- however, the student had to scroll the subcategory list to find it.

Question: **1-19**. Who was leader of France in 1685 and what action occurred that had a significant effect on French religion?

Answer: Louis XIV; revocation of Edict of Nantes and Huguenot privileges

Pages: 321-322

Title: Autocratic Rulers Contrast wi...>French Rulers Expand Their P...>Revocation of the Edict ...

Subject Headings:
France:Huguenots [0], :in seventeenth century [0]
Edict of Nantes [0]
Huguenots [0]
Religion:Catholic-Protestant conflicts and [0]
Louis XIV, king of France [0]

Other Subject Headings:
Religion...
1685 [3]
king of France [1]
France..., :Hundred Years' War and [2], :religious wars in [3]
French religion [1]
leader [1]
Louis [1P]

Question: **2-19**. Who was leader of France in 1801 and what action occurred that had a significant effect on French religion?

Answer: Napoleon; Concordat of 1801

Page: 379

Title: French Revolution and Napoleo...>Napoleonic Program in France>Concordat of 1801

Subject Headings:
Concordat of 1801 [1]
Catholic Church (Roman):in Napoleonic France [0]
Napoleon I (Bonaparte):Catholic church under [0], :law under [1]
France:under Napoleon [1]

Other Subject Headings:
leaders [2]
France..., :under de Gaulle [1], :religious wars in [3], :Consulate government of [3]
France:in American Revolution [1], :in seventeenth century [1]
france [1]
Napoleon III (Louis), emperor of France [1]
Religion..., :tolerance for, in France [1]
Catholic Church (Roman):in France [1]
1801 [2], *1801* [1]
james [1]
henry [1]

Comment: Many students got the first part of the first question correct, i.e. Louis XIV, though only one answered the second part correctly (revocation of Edict of Nantes and Huguenot privileges), possibly because much happened during his reign. The "Divine Right of Kings" might be a possible answer, though it's unclear from the text what effect this had on religion or on politics. Charles II and James II were answers given by students, and both were kings in 1685, but in a different country, England. The second question involved similar indirect strategies: looking under religion, names of leaders, and dates. The pattern **1801** successfully returned the subject *Concordat of 1801*.

Question: **1-20.** What was a reason why the Roman Republic in 265 B.C. was able to achieve and keep their conquests?

Answer: effective military, fairness to conquered, fighting for a just cause

Page: 108

Title: Romans Build an Empire>Roman Republic Develops>Roman Power Spreads Through Italy

Subject Headings:
Roman Empire, the:Republic of [1], :conquests of [2], :military of [0]
Military:of Roman Empire [0]
Rome, Republic of [1]
Italy:Roman republic in [0]

Other Subject Headings:
Roman Empire, the...
Roman Republic (of 1848) [1]

Question: **2-20.** What was a reason why the Roman emperors objected to Christianity?

Answer: refusal to offer sacrifices to the emperors or to recognize them as gods meant threat to authority and political power

Page: 141

Title: Two Great Religions Develop i...>Early Christian Church>Early Christians Die for Their ...

Subject Headings:
Christianity:persecution of [1], :early in [0]
Roman Empire, the:Christianity in [5]

Other Subject Headings:
Christianity..., :in Roman Empire [4]
Roman Empire, the:religion in [3]
Catholic Church (Roman):beginning of [1]
emperors [1]

Comment: The first question involved finding information about the military in Roman Republic (i.e. early Roman Empire). The Roman Republic confusion arose again, although this time "...(of 1848)" should have clearly indicated that it was not the correct one.

In the second question, there are several subject index confusions: *Roman Empire, the:religion in* refers only to early Roman religion, and does not include Christianity; *Christianity:in Roman Empire* refers to Christianity around the 4th century A.D., but no earlier, though the desired information is only a few pages away; *Roman Empire, the:Christianity in* refers to the later information as well as information about early Christians.